MODERN SURGERY

GENERAL AND OPERATIVE

BY

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THIS VOLUME IS

DEDICATED, WITH AFFECTIONATE REGARD, TO

DR. ORVILLE HORWITZ,

THE FELLOW-STUDENT, THE HOSPITAL ASSOCIATE, AND
THE TRUSTED FRIEND OF

THE AUTHOR.

PREFACE TO THE FIFTH EDITION

In making this revision the book has been carefully gone over; many sections have been altered or expanded, and considerable new matter has been added.

Among the sections altered, corrected, or expanded may be mentioned those upon hernia, ulcer of the stomach, cancer of the stomach, ulcer of the duodenum, tetanus, snake bites, syphilis of bones and joints, gonorrhea in children, concussion of the brain, compression of the brain, hydrocephalus, cephalocele, spina bifida, suture of the divided spinal cord, injuries by electricity, fractures of the bones of the foot, surgical tuberculosis, cleft palate, Bier's method of congestive hyperemia, and perforation of the bowel in typhoid fever.

The new matter added includes: Fracture of the carpal scaphoid, dislocation of the semilunar bone, operation for ununited fracture of the femoral neck, operations of Hugier and of Murphy for ankylosis, the treatment of whitlow by the plan of G. B. Mower White, operation for brachial birth palsy, operation for intracranial hemorrhage of the newborn as advocated by Cushing of Baltimore, treatment of neuralgia by injection of osmic acid, Ransohoff's plan of discission of the pleura in chronic empyema, Brophy's operation for cleft palate, artificial stimulation of phagocytosis, scopolamin-morphin anesthesia, local anesthesia by injection of stovain, operation for movable kidney, Monks method of identifying different portions of the small intestine, radium, Willy Meyer's operation for carcinoma of the mammary gland, Young's method of perineal prostatectomy, the interilio-abdominal amputation, Von Mosetig's method of filling bone cavities, the Johns Hopkins operation for inguinal hernia, the Quenu-Mayo operation for rectal cancer, Moynihan's short loop method of gastro-jejunostomy, the no-loop method of gastro-jejunostomy devised by the Mayo brothers, appendicostomy, the transverse incision for exposure of the vermiform appendix, malignant disease of the appendix, typhoid cholecystitis, Matas's operation for aneurysm, and the treatment of peritonitis by incision, drainage, the semi-erect position, and continuous low pressure proctolysis. A number of new cuts have also been added.

2045 Walnut Street, Philadelphia
February, 1907.

PREFACE TO THE FIRST EDITION

The aim of this Manual is to present in clear terms and in concise form the fundamental principles, the chief operations, and the accepted methods of modern surgery. The work seeks to stand between the complete but cumbrous text-book and the incomplete but concentrated compend.

Obsolete and unessential methods have been excluded in favor of the living and the essential. There has been no attempt to exploit fanciful theories nor to defend unprovable hypotheses, but rather the effort has been to present the subject in a form useful alike to the student and to the busy practitioner.

The opening chapter is devoted to Bacteriology because the author profoundly believes that without some knowledge of the vital principles of this branch of science the vast importance of its truths will be ill-appreciated, and there will be inevitable failure in the application of aseptic and antiseptic methods.

Ophthalmology, gynecology, rhinology, otology, and laryngology have not been considered, because of the obvious fact that in the advanced state of specialized science only the *specialist* is competent to write upon each of these branches.

In Orthopedic Surgery are discussed those conditions which must in the very nature of things often be cared for by the surgeon or the general practitioner (such as hip-joint disease, club-foot, Pott's disease of the spine, flat-foot, etc.). The limited space at command precluded the introduction of a special division on diseases of the female breast. A large amount of space has been devoted to Fractures and Dislocations, the enormous practical importance of these subjects calling for their full discussion. Operative Surgery is considered in separate sections, the most important procedures being fully described, giving also the instruments necessary, and the positions assumed by patient and operator. This method has been adopted to fit the work for use in surgical laboratories.

Many systems, manuals, monographs, lectures, and journal articles have been consulted, and credit has been given in the text for statements and quotations. Special acknowledgment is due to the *American Text-Book of Surgery,* edited by Keen and White; to the surgical works of Ashhurst, Agnew, the elder Gross, Duplay and Reclus, Esmarch, Albert, Koenig, Wyeth, and Bryant; to the *Manual of Surgery,* edited by Treves; to the *International Encyclopædia of Surgery,* edited by Ashhurst; to the *Surgical Pathology* of Billroth and of Bowlby; to the *Diagnosis* of A. Pearce Gould; to the *Surgical Dictionary* of Heath; to the *Rest and Pain* of Hilton; to the works on operative surgery of Barker, Jacobson, Treves, Stephen Smith, and Joseph Bell; to the *Minor Surgery* of Wharton; to the dictionary of Foster and of Gould; to the *Principles of Surgery* of Senn; to the orthopedic writings of Sayre;

to the work on *Diseases of the Male Generative Organs* of Jacobson; to the *System of Genito-urinary Diseases*, edited by Morrow; and to the treatises on *Fractures and Dislocations* of Sir Astley Cooper, Malgaigne, Hamilton, Stimson, and T. Pickering Pick.

The Author returns his thanks to the numerous writers who courteously authorized the reproduction of special illustrations, and particularly to Professors Keen and White for their free permission to draw upon the *American Text-Book of Surgery*, from which a number of pictures have been taken, distinctively those referring to Bandaging; to Mr. John Vansant for the great amount of labor so ably and cheerfully performed; and to Dr. Howard Dehoney for the preparation of the Index.

CONTENTS

MODERN SURGERY

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I. BACTERIOLOGY.

Bacteriology is the science of micro-organisms. Though a science in the youth of its years, bacteriology has not only profoundly altered, but it has also revolutionized, pathology, and our views of surgery would be incomplete, misleading, and erroneous without its aid.

Micro-organisms, or microbes, are minute non-nucleated vegetable cells closely connected with fungi and algæ, many of them being visible only by means of a highly powerful microscope and after they have been brightly stained. The contents of these cells are protoplasm and nuclear chromatin enclosed by a structure containing cellulose. There is considerable evidence that some diseases are caused by bacteria so minute as to escape detection even by the most powerful microscope. The French Yellow Fever Commission asserted that the yellow fever micro-organism passes through a porcelain filter ("Annals of the Pasteur Institute," Nov., 1903). The micro-organism of rabies probably does the same thing.

Even in the most remote times some have believed that "the mysterious cause of contagious and epidemic diseases must be sought in living entities" (Monti on "Modern Pathology"). Bacteria were discovered by Leeuwenhoek in 1675, but definite knowledge of these minute bodies and of their actions dates from the study of fermentation by the celebrated Frenchman Pasteur, who in 1858 asserted that every fermentation has invariably its specific ferment; that this ferment consists of living cells; that these cells produce fermentation by absorbing the oxygen of the substance acted upon; that putrefaction is caused by an organized ferment; that all organized ferments are carried about in the air; and that entirely to exclude air prevents putrefaction or fermentation.

In 1860 Pasteur published the observation that sterile liquids will not be contaminated by air if the air gains entry only through a long curved tube, the reason being that dust and growths fall from the entering air by gravity ("Comptes rendus," 1860).

In 1863 Pasteur published his experiments which proved that beer cannot ferment without yeast and that wine received in sterile vessels and kept from external contamination will not undergo ammoniacal change.

The views of Pasteur, which were radical departures from accepted belief, inaugurated a bitter controversy, and in that controversy were born the microbic theory of disease, the doctrine of preventive inoculation, antiseptic surgery, and serum-therapy.

The word *microbe*, which signifies a small living being, was introduced in 1878 by the late Professor Sédillot, of Paris. At that time the nature of these bodies was in doubt; some thought them animal, and called them

microzoaria; others thought them vegetable, and called them *microphyta;* the designation "microbe" does not commit us to either view. We now know them to be vegetable, but the term "microbe" has remained in use.

The micro-organisms connected with disease in man are divided into:

1. Yeasts, Saccharomyces, or Blastomycetes;
2. Moulds, or Hyphomycetes;
3. Bacteria, or Schizomycetes.

Yeasts or **budding fungi** include most of those fungi which can cause alcoholic fermentation in saccharine matter. They consist of small cells which can live without free oxygen, and which multiply by *gemmation or budding.* When a cell multiplies a small bud of protoplasm projects from or near the end of the cell. This bud increases progressively in size and a constriction appears between the bud and the parent-cell. The constriction deepens as the projection enlarges, until the bud attains the size of the parent. Thus a chain or series of rounded yeast-cells is formed. These cells contain spores when nourishment is insufficient. Under certain conditions yeast fungi can form interwoven threads called *mycelial threads.*

Moulds or **filamentous fungi** consist of filaments, each filament being composed of a single row of cells arranged end to end, and all filaments springing from a germinal tube which grows from a germinating spore. The yeast fungi are the common but not the only cause of fermentation. Mould fungi are connected with processes of decomposition. Putrefaction is due to bacteria and retards the growth of yeast and moulds.

Most yeasts and moulds grow best upon dead organic matter, some attack plants, a few the lower animals, and a very few grow upon or in the tissues of the human body.

The *oidium albicans* is an yeast fungus which by growing in the mucous membrane produces the disease known as *thrush.* This disease attacks especially the mucous membrane of the mouth and pharynx, but occasionally the growth takes place upon the esophagus, the vocal cords, the stomach, the vagina, the respiratory tract, and the areola of the breast of a nursing woman. The proliferating fungus presents the appearance of milky white spots which by thickening and coalescence form curd-like masses, the superficial layer of epithelium being raised and cast off.

Blastomycetes dermatitis is an inflammation of the skin due to yeast fungi and bearing a resemblance to tuberculosis or syphilis. Sanfelice and others maintain that yeasts are responsible for the growth of *malignant tumors.* It is certain that yeasts may exist in a carcinoma and can be cultivated, but proof is entirely lacking that they are anything but a contamination. Many skin diseases are due to fungi; among them should be mentioned: *Favus*, pityriasis versicolor, herpes tonsurans, parasitic sycosis, and eczema marginatum.

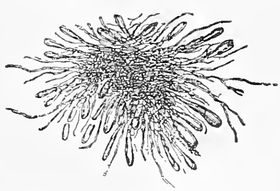


Fig. 1.—Actinomyces (Ziegler).

Actinomycosis is due to the ray-fungus (see page 272). It is uncertain in which group the ray-fungi should be placed; it is quite certain that more than one variety exists, and they seem to occupy a place between moulds and bacteria. *Madura-foot*, or *mycetoma*, is due to the *streptothrix Maduræ.*

Schizomycetes or **bacteria** chiefly claim our attention. It is important to remember that the term "bacteria," though applied to the class *schizomycetes*, has also a more restricted application—that is, to a division of the class; it may mean either *schizomycetes* in general, or rod-shaped *schizomycetes*, whose length is not more than twice their breadth. In this work it is employed to designate *schizomycetes* as a class.

Bacteria are minute, unbranched, non-nucleated, vegetable cells, free from chlorophyl, varying in shape and occasionally presenting locomotive flagella. The cell consists of a *cell membrane*, a *layer of protoplasm*, and some *central fluid*. No true nucleus has yet been demonstrated, but granules are found within the cells which some call *metachromatic bodies* (Babés) and others *nuclei* (Ernst). The cell membrane varies greatly in thickness, and when it is very thick the cell is said to have a *capsule*. The round cells have a smooth outer surface, but some of the rod-shaped cells show many *flagella* or at the end a single flagellum (Fig. 2). Flagella enable some bacteria to move (*motile bacteria*), but all organisms which possess them are not motile, and under certain conditions bacteria without flagella may develop them, or organisms which possess flagella may lose the power to develop them.

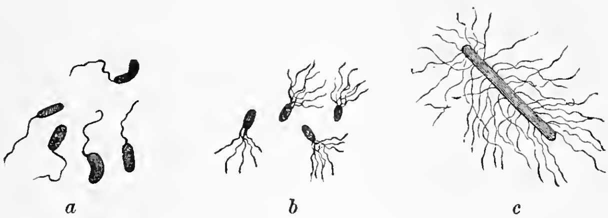


Fig. 2.—Types of flagella. *a*, Vibrio choleræ, one flagellum at the end—monotrichia type; *b*, Bact. syncyaneum tuft of flagella at the end, rarely at the side—Lophotrichia type; *c*, Bact. vulgare, flagella arranged all about—Peritrichia type (Lehmann and Neumann).

Some bacteria, known as *non-pathogenic*, cannot grow and produce poison either in the tissues, in wound-fluid, or in the fluid moistening a mucous surface. Others grow upon dead organic matter, but are not able to invade living tissues. They can live and multiply in the discharge from a wound or in the fluid covering a mucous surface and are called *saprophytes*, *saprophytic microbes*, or *putrefactive bacteria*. *Obligate* saprophytes only live in dead matter and never become parasites. *Facultative* saprophytes can be parasites and can also grow in dead organic matter. Bacteria, known as the *pathogenic*, under certain conditions invade living tissue and cause various diseases. *Parasitic* bacteria can grow on or in the tissues of the body. *Obligate* parasites are those which have not been cultivated outside of the body (as the bacilli of leprosy). *Facultative* parasites usually live outside the body, but may enter into the body and produce disease. The schizomycetes vary much in shape, size, color, arrangement, mode of growth, and action upon the body. One form cannot be transformed into another, but each maintains its specific identity. Every organism comes from a pre-existing organism, this being true of all forms. Pasteur proved that spontaneous generation is impossible. The protoplasm of these cells can be stained with anilin colors, and the cell-wall is more readily detected after treating it with water, which causes it to swell.

Many bacteria are colored; others are colorless. Some move (*motile bacteria*); others do not move (*amotile bacteria*). The bacilli of anthrax and tuberculosis and all cocci are amotile. Most bacteria can change from motile to amotile, or from amotile to motile, when subjected to certain changes of soil and environment. The oscillations of cocci are physical in nature, not vital; they are Brunonian or Brownian movements, movements due to alterations in equilibrium because of currents or changes of level in the fluid in which the micro-organisms are contained. Bacteria seem to possess the power of attracting elements necessary for their nutrition (*positive chemiotaxis* or *chemotaxis*) and of repelling harmful elements (*negative chemiotaxis* or *chemotaxis*).

Fig. 3.—Micrococci.

Fig. 4.—Bacilli.

Fig. 5.—Spirilla.

Forms of Bacteria.—The three chief forms of bacteria are—

1. The *Coccus* or *Micrococcus*—the berry-shaped, oval, or round bacterium (Fig. 3);

2. The *Bacillus*—the rod-shaped bacterium (Fig. 4);

3. The *Spirillum* or *Vibrio*—the corkscrew-shaped or spiral bacterium (Fig. 5). A short spiral organism is called a *comma bacillus*.

De Bary compares these forms, respectively, to the billiard-ball, the lead-pencil, and the corkscrew.

Cocci and Bacilli.—As surgeons we have to do only with *cocci* and *bacilli*. Cocci may be designated according to their arrangement with one another;

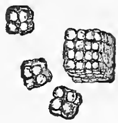


Fig. 6.—Sarcinæ forming bales of packets. Single packets regularly grouped together (Lehmann and Neumann).

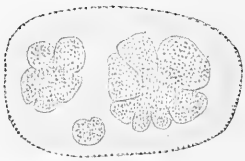


Fig. 7.—Ascococcus Billrothii Cohn (after F. Cohn).

namely, when existing singly they are called *monococci* (Fig. 3); in pairs they are called *diplococci* (Fig. 8, A); arranged end to end in a chain they are called *streptococci* (Fig. 8, C); in group side by side clustered like a bunch of grapes they are called *staphylococci* (Fig. 8, B); in groups of four they are called plate *cocci*, or *tetracocci;* in cubical groups they are called *sarcinæ* or *wool-sack* cocci (Fig. 6). Irregular masses, resembling frog-spawn, constitute *zoöglea masses* (Fig. 9). The gelatinous matter in such a mass is formed by a transformation in the walls of the bacteria. The term *ascococci* is applied to a group of cocci enclosed in a capsule (G. S. Woodhead) (Fig. 7).

The cocci are often named according to their function, as, for example, "*pyogenic*," or pus-forming. Cocci may be named according to the color of the culture. The name may embody the form, arrangement, color, and function; for instance, *Staphylococcus pyogenes aureus* signifies a round, golden-yellow micro-organism, which arranges itself with its fellows in the form of a bunch of grapes, and which produces pus.

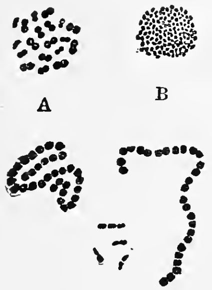


Fig. 8.—Forms of cocci.

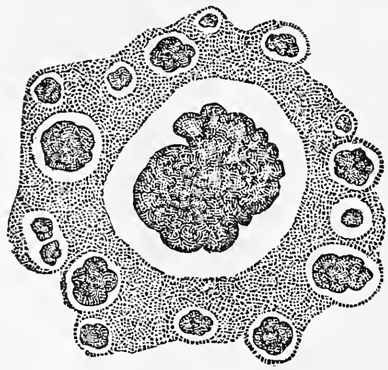


Fig. 9.—Zoöglea (Ball).

The *bacilli* are long, staff-shaped organisms. Long, delicate, jointed bacilli having wavy outlines are known as *leptothrix* forms. Chain-like bacilli are called *streptobacilli*. Bacilli give origin to many surgical diseases.

Dichotomy or Branching.—It is very seldom that a side bud appears upon bacteria except in the bacteria of tuberculosis and diphtheria.

Pseudodichotomy is by no means unusual. It occurs when one end of a bacillus grows by the end of the adjacent bacillus or when a bacillus in a chain divides in a line parallel to the chain and thus begins another chain (Fig. 10).

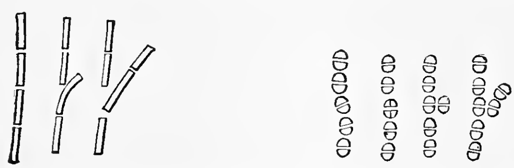


Fig. 10.—Pseudodichotomy. *a*, In bacilli; *b*, in streptococci (Lehmann and Neumann).

Multiplication of Bacteria.—Bacteria multiply with great rapidity when placed under suitable conditions. They can multiply by transverse fission or by spore-formation. Some bacteria multiply by both methods. In *fission*, or *segmentation*, a bacillus undergoes an increase in size and length; a coccus does not increase in size but slightly elongates. In either case about the middle of the cell a transverse constriction begins, which deepens until the cell has divided into two parts, each of which soon grows as large as its parent (Figs. 11, 12). As a rule, the micro-organisms separate after division of the cell; but they may not do so; and if they do not separate, the special grouping

receives a particular name (diplococci, streptococci, etc.). If the division is invariably in the same direction, and if the new cells remain in contact, streptococci or streptobacilli are formed. Tetracocci and sarcinæ are formed when a number of cocci "divide in two or three successively vertical directions" ("Clinical Bacteriology," by Levy and Klemperer), forming four quadrants (*tetracocci*) or eight octants (*sarcinæ*). All cocci and some bacilli multiply by fission.

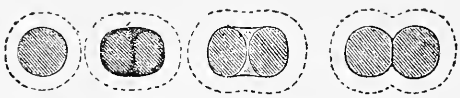


Fig. 11.—Divisions of a micrococcus (after Macé).

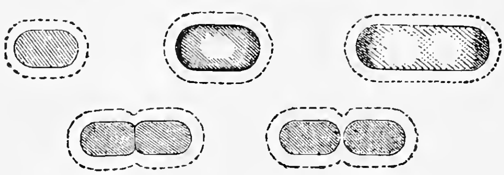


Fig. 12.—Divisions of a bacillus (after Macé).

If segmentation of a single cell and the growth to maturity of its products require one hour (it really takes place in less time, the cholera bacillus requiring but twenty minutes to divide), a single cell in a single day, if the conditions for increase were ideally favorable, would have 16,000,000 descendants, and in three days the mass of new cells would weigh 7500 tons (Cohn). In order, however, for such enormous multiplication to occur conditions would have to be absolutely favorable to the cells, and conditions are never absolutely favorable. Were it otherwise, all other forms of life would be destroyed. During growth in a culture medium the products of bacteria are detrimental to the bacteria themselves. In a culture of cholera bacilli the number of living microbes begins to lessen after twenty-four hours, and after forty-eight hours the diminution is distinct.

Spores.—A *spore* is a germ, and corresponds with the seed of a plant. Some bacilli, a few spirilla, and it may be sarcinæ, multiply by spore-formation. Cocci do not undergo spore-formation after the manner of bacilli, though some observers maintain that cocci occasionally undergo an alteration that makes them very resistant to any destructive influences. When spore-formation is about to occur in a bacillus, a point of cloudiness or an area of bright refraction appears in the protoplasm and the cell generally elongates. When a row of cells sporulate, the segments, each of which contains a lustrous area or a region of cloudiness, look like parts of a necklace of beads (Fig. 13).

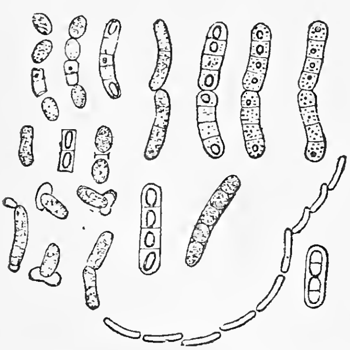


Fig. 13.—Sporulation (after De Bary).

The spore enlarges, the cell membrane bursts, and the young bacillus emerges

through the opening. A cell usually contains but one spore, which may be situated at the end of the cell (*endspore*) or in the middle of the cell (*endospore*). Sometimes a single cell contains several spores. If an endspore exists, the end of the cell containing the spore is swollen or club-shaped (*drumstick bacterium*). If an endospore exists, the cell becomes spindle-shaped (*clostridium*). When multiplication is by a single endospore, the bacillus does not elongate. When multiplication takes place by a process of combined spore-formation and fission, the mother-cell divides into a number of daughter-cells, which are called *arthrospores*. Organisms which when active multiply by fission take on spore-formation when subjected to certain conditions.

Spore-formation tends to occur when bacilli are about to die for want of nourishment or when there is an excess of oxygen present. The spore has a dense envelope or covering which is very resistant to destructive agents. So resistant is the covering that twice the amount of heat is necessary to kill a spore as to kill an active adult cell. Spores when placed under conditions unfavorable for development may remain inactive for an indefinite period, just as seeds remain inactive when unplanted. When spores encounter favorable conditions, they at once develop into adult cells, just as seeds develop when planted. It seems probable that spores occasionally remain dormant in the human body for long periods, and finally awaken into activity because of injury or disease of the tissue in which they lie.

Chemical Composition of Bacteria.—The protoplasm of bacteria consists of water, salts, albuminous material, extractives soluble in alcohol, and extractives soluble in ether.

Life-conditions of Bacteria.—In order to grow and to multiply, bacteria require a suitable soil and the favoring influences of heat and moisture. The soil demanded consists of highly organized compounds rather than crude substances, and slight modifications in it may prove fatal to some forms of bacterial life, but highly advantageous to others. Some organisms require albuminous matter, others need carbohydrates; they all require water, carbon, nitrogen, oxygen, hydrogen, and certain inorganic materials, especially lime and potassium (Woodhead). All organisms require water. If dried, no micro-organisms will multiply, and many forms will die. The fluids and tissues of the individual may or may not afford a favorable soil for the germs of a disease, or, in the same person, may afford it at one time and not at another. Some individuals seem to possess indestructible immunity from, and others are especially prone to, certain bacterial diseases. Impairment of health, by altering some subtle condition of the soil, may make a person liable who previously was exempt. Injury or disease of a tissue may increase local liability.

Again, some bacteria which under normal conditions are harmless may become virulent under certain conditions. Colon bacilli, which under normal conditions seem to be putrefactive organisms inhabiting the intestine, may attack a point of least resistance in the intestine itself; this point being established by congestion, strangulation, inflammation, or injury, and descendants of the bacteria which attacked the point of least resistance may become so virulent that they can live and develop in tissues distant and apparently normal and cause disease in them.

The presence of oxygen influences microbic growth. Most organisms

thrive best when exposed to the oxygen of the air, and they are known as *aërobic.* The term *anaërobic* is employed to designate organisms that can grow and multiply and produce particular products only when air is absent, free oxygen being fatal to them. Tetanus bacilli and the bacilli of malignant edema are anaërobic. An organism which grows best in air but can grow when free oxygen is excluded is called a *facultative-aërobic bacterium.* It may need oxygen; but if it does, it is able to obtain it from the tissues when air is excluded. A sensitive organism which dies when the amount of oxygen is even slightly diminished is called an *obligate-aërobic bacterium.* Most microbic diseases in man are due to facultative-aërobic bacteria.

Effect of Motion, Sunlight, the X-rays, Cold, and Heat.—The majority of fungi grow best when at rest; violent agitation retards the growth of some. Sunlight antagonizes the growth of certain bacteria, especially tubercle bacilli and the bacilli of typhoid fever. It is claimed by some that the *x*-rays retard bacterial growth. Temperature influences bacterial growth. Some organisms will grow only within narrow temperature-limits, while others can sustain sweeping alterations, but most grow best between the limits of from 86° to 104° F. Freezing renders bacteria motionless and incapable of multiplication, but it does not kill them: they again become active when the temperature is raised. Prudden showed that typhoid bacilli can live in ice one hundred and three days. The absurdity of employing cold as a germicide is evident when the fact is known that a temperature of 200° F. below zero is not fatal to germ-life, cell-activities by such a temperature only being rendered dormant. Bacteria have been placed in hermetically sealed tubes and the tubes immersed in liquid air for seven days. The germs were thus subjected to a temperature of —190° C., but there was no change produced in their virulence (A. MacFayden and S. Roland, in "Lancet," March 24, 1900). High temperatures are fatal to bacteria; moist heat is more destructive than dry heat, and adult cells are more easily killed than spores. A temperature less than 212° F. will kill many organisms, and boiling will kill every pathogenic organism that does not form spores. Some spores are not destroyed after prolonged boiling, and some will withstand a temperature of 120° C. As a practical fact, however, boiling water kills in a few minutes all cocci, most bacilli, and all pathogenic spores; though the spores of anthrax, tetanus, and malignant edema are harder to kill than are the spores of other bacteria.

Effect of Bacteria upon Bacteria.—Some bacteria are antagonistic to others, some are synergistic to others. The streptococcus of erysipelas is antagonistic to the bacillus of anthrax and also to syphilis and tuberculosis. The growth of some microbes in culture-media makes a soil favorable or unfavorable for other microbes, and the same process may occur in the human body. Influenza renders the lungs prone to infection with pneumococci. Saprophytes on mucous surfaces are antagonistic to certain pathogenic bacteria. We are not yet able to cure a microbic disease by inoculating the sufferer with antagonistic microbes, on the principle of sending a thief to catch a thief.

Latent Bacteria.—Sometimes pathogenic organisms remain latent in the body for a considerable time. They are not destroyed but produce no symptoms, or only local symptoms, possibly because the individual is immune for the time being. Pneumococci, staphylococci, and typhoid bacilli may become latent. Tubercle bacilli may remain latent in a lymph-gland.

Mixed Infection.—A fact of practical importance to the surgeon is that an area infected by one form of micro-organism may be invaded by another form. This is known as a *mixed* infection, and consists in a *primary* infection with one variety of organism, and a *secondary* infection with another, or in an infection at the same time with different micro-organisms. Mixed infection is especially common on surfaces exposed to air and wound infection is usually mixed. Koch found both bacilli and micrococci in the same lesion of tuberculosis. A soil filled with pneumococci favors the growth of pus cocci and tubercle bacilli. Tuberculous or syphilitic lesions may be attacked by erysipelas. Chancre and chancroid can exist together. A syphilitic ulcer is a good culture-soil for tubercle bacilli (Schnitzler). Suppuration in lesions of tuberculosis is due to secondary infection with pus organisms. Occasionally in empyema and other conditions due to pus organisms the diseased process ceases to be active, the pyogenic bacteria having lost much of their virulence, but a mixed infection with some germ usually harmless may break down surrounding barriers, intensify the virulence of bacteria, and aggravate the disease into an acute outburst. When secondary infection occurs the primary infection may remain, may be destroyed, or may be disseminated.

Intra-uterine or Placental Infection.—The infection of the embryo by the diseased ovum or the diseased sperm-cell occurs only in syphilis. Such an embryo is diseased at the first moment of life. The direct transmission of bacteria from parent to fetus is a problem still in course of solution. Certain it is that some diseases may follow the transmission of the micro-organism through the septum of separation between the circulations of the mother and child. Placental transmission may occur in syphilis, scarlatina, pneumonia, anthrax, measles, pyogenic conditions, and tuberculosis (Hektoen). The transmission of tuberculosis is very rare and few cases of congenital tuberculosis have been reported. Commonly, the bacilli are not directly transmitted from a tuberculous mother to the embryo, the child is born free from tuberculosis but with weakened tissue-cells that easily fall a prey to the tubercule bacillus when it reaches them by any avenue. Placental transmission of bacteria is favored by disease or injury of the placenta.

Chemical Antiseptics and Germicides and Aseptic Agents.—It is necessary to make a distinction between deodorizers, antiseptics, and germicides, although the two later terms are usually regarded as being interchangable. In the methods of antiseptic surgery we use germicides.

A *deodorizer* is an agent which destroys an offensive odor. It is true that an offensive odor may be due to microbic growth. It is also true that nasty odors may prove injurious to those who inhale them. But, nevertheless, the odor is the result of microbic action, and destroying an odor does not render harmless the bacteria which caused it. Charcoal is a well-known deodorizer.

An *antiseptic* is an agent which retards or prevents putrefaction. It acts by weakening or killing saprophytic organisms, but is not fatal to spores.

A *germicide* or *disinfectant* is an agent which is fatal to adult bacteria and spores. The destruction of the germs of the disease in clothing, in excreta, in a wound, etc., is known as *disinfection*. Disinfection of a wound, dressings, or instruments is called also *sterilization*.

Antiseptics and germicides should not be used in clean wounds. Repair will occur more quickly if they are not used. Tillmanns has pointed out that

when antiseptics are used cell-division is late in beginning and is slow in progress. Neither are germicides efficient in fatty tissue, as bacteria surrounded with oil cannot be reached by the drug, and the chemical is irritant and apt to cause fat necrosis (Haenel, in "Deutsch. med. Woch.," 1895, No. 8).

Corrosive Sublimate.—Many chemical agents will kill bacteria, one of the most certain of them all being *corrosive sublimate*. Koch showed that corrosive sublimate is an efficient test-tube germicide when present in the proportion of only 1 part to 50,000. It is used in surgery in strengths of 1 part of the salt to 1000, 2000, 3000, or more parts of water. Badly infected wounds are occasionally irrigated with solutions of a strength of 1 to 500. Contact with albumin precipitates from a solution of corrosive sublimate an insoluble albuminate of mercury which forms a white layer upon the surface of the wound, is not a germicide, and prevents deep diffusion of the mercurial fluid. In surgical operations by the antiseptic method the mercurial salt should be combined with tartaric acid in the proportion of 1 to 5, which combination prevents the formation of the insoluble albuminate of mercury.

But though corrosive sublimate under certain conditions is extremely powerful, it is not always absolutely reliable. Many spores are very resistant to its action. Even a 1 per cent. solution of bichlorid of mercury is not certainly destructive to the spores of anthrax. Geppert tells us that anthrax-spores may be active after a twenty-five hour immersion in a 1 : 100 solution of sublimate (Schimmelbusch). In the presence of hydrogen sulphid corrosive sublimate is useless, inert and insoluble sulphid of mercury being precipitated; hence corrosive sublimate is without value as a rectal antiseptic; in fact, Gerloczy has proved that a concentrated aqueous solution of sublimate will not disinfect an equal quantity of feces. Corrosive sublimate contained in dressings after a time undergoes decomposition and ceases to be a germicide. It is not germicidal in fatty tissues because it is unable to attack bacteria which are coated with oil. Corrosive sublimate is very irritating to the tissues and causes copious exudation. Hence, after tissues have been irrigated with this agent drainage must be employed. In some cases the irritated tissues lose to a great extent their power of resistance to bacteria and infection may be actually facilitated by irrigation with sublimate. In rare instances corrosive sublimate is absorbed and produces poisoning. In spite of these shortcomings and drawbacks it is a valuable aid to the surgeon and must be frequently used, especially upon the skin of the patient and the hands of the operator and his assistants. It should be dissolved in distilled water, because ordinary water causes a precipitate to form (common salt prevents the formation of this precipitate).

Because of the fact that corrosive sublimate is poisonous and very irritant, it should not be used upon serous membranes. It is absorbed quickly from serous membranes and destroys the endothelial cells and should not be introduced into the pleural sac, into joints, or into the peritoneal cavity. It should never be put within the dura, and should not be applied, in strong solution at least, to mucous membranes. It should not be introduced into the rectum for three reasons. First, it is intensely irritant and causes pain and inflammation. Second, it is useless, being largely and promptly converted into insoluble and inert sulphid of mercury. Third, a poisonous dose may be absorbed. Instruments cannot be placed in corrosive sublimate without being

dulled, stained, and corroded. It is better to make the solution when it is needed, so as to have it fresh, for in old solutions much of the soluble corrosive sublimate has been converted into insoluble oxychlorid, and the fluid has ceased to be germicidal. In order to make up fresh solutions use tablets, each of which contains about $7\frac{1}{2}$ grains of the drug—one of these tablets added to a pint of water makes a solution of a strength of 1 to 1000. Tablets which also contain ammonium chlorid are more soluble than those which contain corrosive sublimate only. Hot solutions of the drug are more powerfully germicidal than cold solutions. As corrosive sublimate is irritant, leads to profuse exudation, and may produce tissue-necrosis, it should never be introduced into an aseptic wound. In such a wound it can do no good and may do much harm.

Griffin, in Foster's "Practical Therapeutics," sets forth the strengths of solutions applicable to different regions:

For disinfection of the surgeon's hands and the patient's skin, 1 : 1000; for irrigating trivial wounds, 1 : 2000; for irrigating larger wounds and cavities, 1 : 10,000 to 1 : 5000; for irrigating vagina, 1 : 10,000 to 1 : 5000; for irrigating urethra, 1 : 40,000 to 1 : 20,000; for irrigating conjunctiva, 1 : 5000; for gargling, 1 : 10,000 to 1 : 5000.

Corrosive Sublimate Poisoning.—Corrosive sublimate may be absorbed from a wound, a serous surface, or a mucous membrane, ptyalism and diarrhea resulting. The absorption of bichlorid of mercury may be followed by cramp in the limbs and belly, feeble pulse, cold skin, extreme restlessness, and even collapse and death. At the first sign of trouble withdraw the drug and treat the ptyalism (page 291).

Lithiomercuric Iodid.—This material was prepared and tested by Dr. Rosenberger and Mr. England ("American Medicine," 1904, page 1021). It is more powerfully germicidal than corrosive sublimate, it does not form inert albuminate when placed in a wound, and is not precipitated by alkalies. It is not nearly so irritant nor so poisonous as corrosive sublimate. I have given it an extensive trial in my clinic and am satisfied that it is superior to corrosive sublimate as a germicide and is far less irritant and poisonous. Its only objection is that it is more expensive.

Carbolic Acid.—Carbolic acid is a valuable germicide in the strength of from 1 : 40 to 1 : 20. It is certainly fatal to pus-organisms, but weak solutions fail to kill most bacteria and do not destroy spores. Unfortunately, this acid attacks the hands of the surgeon; consequently in the United States it is chiefly employed as a solution in which to place the sterilized operating instruments, or as a germicide to prepare the skin of the patient before the operation is performed.

Carbolic acid is very irritant to tissues, and carbolized dressings may be responsible for sloughing of the wound or dry gangrene. Because of its irritant properties wounds which have been irrigated with it should be well drained. Carbolic acid, like corrosive sublimate, is inert in fatty tissues.

Pure carbolic acid is a reliable disinfectant for certain conditions. It is used to destroy chancroids, to purify infected wounds and abscess cavities, to disinfect the medullary cavity in osteomyelitis, to stimulate granulation after the open operation for hydrocele, or to purify sloughing burns or ulcerated areas. The pure acid rarely produces constitutional symptoms, but it occa-

sionally causes sloughing. Its application causes pain for a moment only, and then analgesia ensues. Even dilute solutions of carbolic acid greatly relieve pain when applied to raw surfaces. The local action of carbolic acid can be at once antidoted by the application of *alcohol* (Seneca D. Powell). When carbolic acid is applied to a wound, the area about the wound should first be moistened with alcohol. After the application of pure carbolic acid to a joint, a wound, the medullary canal, or an infected area, the surgeon should wait about one minute and then apply alcohol.

Carbolic acid acts more slowly and less certainly than corrosive sublimate. It requires twenty-four hours for a 5 per cent. solution to kill anthrax-spores. Pus or blood (albuminous matter) greatly weaken the germicidal power of carbolic acid, and fatty tissue cannot be disinfected by it. It is not even the best of agents in which to place instruments, as it dulls them. After operation upon the mouth it may be used as a wash or gargle, 1 to 2 per cent. being a suitable strength. It is used sometimes to irrigate the bladder and often to cleanse sinuses, but is not employed in the peritoneal cavity, the pleural sac, the rectum, or the brain. It is occasionally injected into tuberculous joints. Carbolic solution should never be used in clean wounds.

Carbolic Acid Poisoning.—Carbolic acid is readily absorbed, and may thus produce toxic symptoms. Absorption is not uncommon when the weaker solutions are used, but seldom occurs when a wound has been brushed over with pure acid, because the pure acid at once forms an extensive zone of coagulated albumin, which acts as a barrier to absorption. One of the early indications of the absorption of carbolic acid is the assumption by the urine of a smoky, greenish, or blackish hue. This hue appears a little time after the urine has been voided, whereas the smoky hue of hematuria is noted in urine at once after it has been passed. The condition produced by carbolic acid is known as *carboluria*, and examination of such urine shows a great diminution or entire absence of sulphates when the acidulated urine is heated with chlorid of barium. The diminution of precipitable sulphates is explained by the fact that these salts are combined with carbolic acid, forming soluble sulphocarbolates (Griffin). Such urine is apt to contain albumin. If during the use of carbolized dressing or the employment of carbolic solutions the urine becomes smoky, the use of the drug in any form must be at once discontinued, otherwise dangerous symptoms will soon appear. These symptoms are subnormal temperature, feeble pulse and respiration, muscular weakness, and vertigo. If death occurs, it is due, as a rule, to respiratory failure. The treatment of slow poisoning by carbolic acid consists in at once withdrawing the drug, giving stimulants and nourishing food, administering sulphate of sodium several times a day and atropin in the morning and evening.

Saline Solution.—Sodium chlorid solution of normal strength (0.7 of 1 per cent.) does not damage the cells of serous surfaces or of a wound hence it is used as an irrigating fluid, and it is the best fluid for such a purpose. In intravenous infusion, in shock or hemorrhage it is very valuable. It does not damage the blood-corpuscles as plain water does. It is, however irritant to the kidneys, when used by hypodermoclysis or intravenous infusion; hence plain boiled water should be used for the former and saline fluid of one-half normal strength for the latter purpose. Normal salt solution is prepared as follows: A quart of water is filtered and sterilized and in this $1\frac{1}{2}$ drachms of table salt are dissolved, and the fluid is again boiled.

Thiersch's Fluid.—This fluid is used upon mucous and serous surfaces and is employed to irrigate wounds. It is non-toxic and non-irritant. It consists of 1 grain of salicylic acid and 6 grains of boric acid to 1 ounce of water.

Alcohol.—Alcohol is a germicidal agent, which is most powerful when of the strength of 70 per cent. It may be used on the hands or the skin of the patient, of a strength of from 70 per cent. to 95 per cent., and may be used plain or mixed with corrosive sublimate, of the strength of 1 to 1000. Pure alcohol is used to arrest the local action of pure carbolic acid.

Boiled Water.—Is used to dissolve antiseptic materials; to inject by hypodermoclysis; to irrigate wounds, mucous cavities or serous surfaces, and as a fluid in which to keep instruments during the operation. It damages somewhat the tissue-cells of the surface of a wound and injures the cells of serous surfaces, hence for irrigation salt solution is to be preferred.

Creolin, which is a preparation made from coal-tar, is a germicide without irritant or toxic effects. It is less powerful than carbolic acid, but acts similarly and is used in emulsion of a strength of from 1 to 5 per cent., and does not irritate the skin like carbolic acid.

Peroxid of hydrogen is an excellent agent for cleansing a purulent or putrid area, but it is never applied to an aseptic wound. It is prepared in a 10-volume solution, which should be diluted one-half or two-thirds before using. It probably destroys the albuminous element upon which bacteria live, and thus starves the fungi. When peroxid of hydrogen is applied to a purulent area ebullition occurs, liberated oxygen bubbling up through the fluid and the pus being oxidized. The peroxid reaches every cranny and diverticulum containing pus. The peroxid of hydrogen is not fatal to tetanus bacilli; in fact, tetanus bacilli can be cultivated in a strong solution of it. It is very valuable as a mouth wash to cleanse the mouth before and after operations in the oral cavity. Some surgeons use it to wash out appendicular abscesses (R. T. Morris). It must not be injected into a deep abscess in any region unless a large opening exists, as otherwise the evolved gas may tear apart structures, dissect up the cellular tissue, and spread infection. The use of peroxid should not be too long continued, for if used for a considerable period it makes the granulations edematous and retards healing. In fact, its continued use may actually prevent a sinus closing.

Iodoform.—Iodoform is largely used by surgeons in spite of the fact that laboratory workers have assured us it is not truly a germicide as bacteria will grow upon it. Clinical evidence, however, is in its favor and surgeons long ago concluded that it at least hinders the development of bacteria, directly antagonizes the action of the toxic products of germ-life, and stimulates the production of connective tissue. It is of the greatest value when applied to putrid foci, suppurating areas, and tuberculous processes. In putrid foci it probably combines with toxins and renders them less poisonous or even inert.

It attenuates the virulence of pus cocci and organisms of putrefaction. It renders its greatest service in tuberculous processes and is infinitely more powerful when oxygen is excluded than when it is present. The laboratory workers who condemn it have in many cases used nutrient material in which it does not dissolve (P. F. Lomry, "Archiv für klin. Chir.," 1896). D. B. Heile ("Proceedings of the German Surgical Congress of 1903") insists that iodoform is a valuable germicide if oxygen is excluded. He says, if iodoform

is mixed with tissue juice, oxygen being excluded, the mixture becomes powerfully germicidal, even to streptococci in from three to five days, although neither constituent of the mixture when alone is germicidal. Tissue juice decomposes iodoform, liver juice decomposing it most rapidly, brain and fat decomposing it slowly. Granulation tissue decomposes it and tuberculous granulation tissue acts upon it most rapidly.

The conclusion of Heile is that this study confirms the clinical observation that iodoform is valuable in cavities but not in free surfaces. My own belief is that it is more valuable in cavities than upon free surfaces, but when we are dealing with putrefactive areas, even on free surfaces, it is of great value. Heile maintains that when iodoform decomposes on a free surface it sets free I, which is not a powerful germicide. When it decomposes in tissue juice it sets free di-iod-acetylene, a powerful germicide which is rendered inert by oxygen. Clinically, no real substitute for iodoform has yet been found. It can be rendered sterile by washing with a solution of corrosive sublimate solution. It need not be applied to clean wounds, but the powder is very useful when dusted into infected wounds. It prevents wound-discharges from decomposing and distinctly allays pain. Gauze impregnated with iodoform is used to keep abscesses open after evacuation, to drain the belly after certain operations, to pack aside the intestines and prevent their infection during some abdominal operations, and as packing to arrest intracranial hemorrhage. Iodoform gauze will drain serum well, but will not drain pus. In fact, it blocks up a pus-cavity, and if retained long leads to the collection of purulent matter behind and about the supposed drain. If used in an abscess, it must be removed in twenty-four or thirty-six hours. Tuberculous joints and cold abscesses are injected with iodoform emulsion, which is made by adding the drug to sterile glycerin or olive oil. The emulsion contains 10 per cent. of iodoform. A solution in ether of a strength of 10 per cent. may be used to inject the cavity of a cold abscess, but it is dangerous, may rupture the wall, and is more apt to produce poisoning than is the emulsion.

Iodoform-poisoning.—The drug must be used with some caution. Absorption from a wound sometimes happens, producing toxic symptoms. These symptoms are frequently misinterpreted, being usually attributed to infection. R. T. Morris has pointed out that in iodoform-poisoning the wound seems to be in excellent condition, whereas in sepsis the wound is unhealthy. The symptoms in some cases are acute and arise suddenly, and consist of hallucinatory delirium, nausea, fever, watery eyes, contracted pupils, metallic taste in mouth, yellowness of the skin and eyes, an odor of iodoform upon the breath, the presence of the drug in the urine, the outbreak of a skin eruption resembling measles or one which is erythematous, vesicular, bullous, or petechial. There is often nephritis and always excessive loss of flesh and strength. Patients with such acute symptoms usually pass into coma and die within a week. Such attacks are most apt to arise in those beyond middle life (see Gerster and Lilienthal, in Foster's "Practical Therapeutics"). Iodin can be recognized in urine by adding a few drops of commercial nitric acid and a little chloroform. When the mixture is shaken the chloroform will take up the free iodin and become purple, and on standing the purple layer will settle to the bottom of the tube. Another method is as follows: Put a little urine in a saucer, add a little calomel, and stir. If the urine contains iodoform a brown color will

be noted (R. T. Morris). The finding of iodin in the urine, however, is not proof that the patient is poisoned. We may find it when no sign of poisoning exists. In chronic cases of iodoform-poisoning the first symptoms usually observed are moroseness, bewilderment, and irritability, followed by depression, with unsystematized persecutory delusions, delirium, coma, and even death.

In systemic poisoning by iodoform, discontinue the use of the drug, sustain the strength of the patient, and favor the elimination of the poison.

Iodoform sometimes produces greal local irritation of the cutaneous surface, the dermatitis being eczematous or else being manifested by crops of vesicles filled with turbid yellow serum or even bloody serum. These vesicles rupture and expose a raw oozing surface, looking not unlike a burn. The use of the drug must be at once abandoned, for to continue it will not only increase the dermatitis, but may produce constitutional symptoms. Wash the vesiculated area with ether to remove iodoform, open each vesicle, and dress the part for several days with gauze wet with normal salt solution. After acute inflammation ceases apply zinc ointment or cosmolin.

Aristol is an odorless iodin compound used by some as an antiseptic dusting-powder.

Loretin is an antiseptic powder which is odorless, germicidal, non-irritant, and which is said to be non-toxic.

Europhen is a powder containing iodin, and the iodin separates from it slowly when the powder is applied to wounds or burns. It does not produce toxic symptoms readily, if at all, and is a valuable substitute for iodoform. It is used especially in the treatment of ulcers and burns.

Nosophen is a pale yellow powder containing 60 per cent. of iodin. Its bismuth salt is known as **antinosin.** Nosophen is not toxic, is free from odor, and is the best of the substitutes for iodoform.

Acetanilid is frequently used as a substitute for iodoform. It is of value when applied to suppurating, ulcerating, or sloughing areas, but it does not benefit tuberculous conditions. Sometimes absorption takes place to a sufficient extent to cause cyanosis, sweating, and weakness of the pulse and respiration. If cyanosis arises, suspend the administration of the drug and administer stimulants by the stomach.

Airol is a substitute for pure iodoform, and is composed of gallic acid, bismuth, and iodoform. It is non-irritant and non-toxic.

Among other powders we may mention iodol, amyloform, subiodid of bismuth, and dermatol or subgallate of bismuth.

Silver is a valuable antiseptic. Halsted and Bolton have shown that metallic silver exerts an inhibitive action upon the growth of micro-organisms and does not irritate the tissues. Credé has also demonstrated the same facts. These statements indicate one great reason why silver wire is such a useful suture-material. Halsted is accustomed to place silver foil over wounds after they have been sutured, and Credé employs as a dressing a fabric in which metallic silver is intimately incorporated.

Credé considers silver lactate (**actol**) an admirable antiseptic. It does not form an insoluble albuminate when introduced into the tissues and is not an irritant. Silver citrate (**itrol**) is said to be even a better preparation than silver lactate, and it is a useful dusting-powder. A preparation of metallic silver, known as *colloidal silver* or *collargolum*, is made. This prepa-

ration is soluble in water and in albuminous fluids; it remains as metallic silver when in solution, and is said to be powerfully germicidal. It certainly seems to cause leukocytosis and to stimulate phagocytosis. It comes put up in 1 and 2 grain tablets. A solution of the strength of from 1 to 5 per cent. is used. In severe cases of sepsis this solution is injected into a vein which has been rendered prominent by applying a bandage above the elbow. The dose is from 1 to 2 grains of the drug. One injection or more may be given. Some have given it subcutaneously, others by enema. **Credé's ointment of silver** is used in septic diseases and seems to be of value. In a child 15 grains, in an adult 45 grains of the ointment is rubbed in the skin at one time, and the rubbing should be kept up from ten to thirty minutes. There is said to be no risk of argyria. **Protargol** is a silver salt much used in gonorrhea. A solution in water is made. It is not precipitated by albumin, alkalies, nor acids. In gonorrhea a 1 to 5 per cent. solution is used. **Argyrol** is a new and valuable preparation of silver which I have used frequently with much satisfaction. It is known as silver vitelline, is not irritant, and contains 30 per cent. of metallic silver. It is not precipitated by albumin. In a strength of 5 per cent. it is a very useful injection for gonorrhea, as it has powerful gonococcidal properties. In some types of chronic cystitis several drams of a 3 per cent. solution may be injected into the bladder from time to time, and much stronger solutions can be used with safety. Inflamed mucous membranes may be painted with a solution of a strength of from 20 to 50 per cent. A sinus or a sluggish area of granulation may be stimulated by touching with a solution of a strength of from 25 to 50 per cent. I have found it of much service in sinuses.

Formaldehyd, or **formic aldehyd,** has valuable antiseptic properties. **Formalin** is a 40 per cent. solution of the gas in water. Solutions of this strength are very irritant to the tissues, but 1 per cent. solutions can be used to disinfect wounds. A solution of a strength of 0.5 per cent. is used to irrigate sinuses, tuberculous areas, abscess-cavities, and suppurating joints. A strong solution is used to asepticize chancroids and other ulcers. A 2 per cent. solution disinfects instruments. The vapor of formalin can be so applied as to disinfect wounds, and Wood suggests its employment in septic peritonitis as a means of disinfection after the abdomen has been opened. The vapor of formalin thoroughly disinfects catheters.

Formalin-gelatin was introduced by Schleich as an antiseptic powder. The commercial preparation is known as **glutol.** When applied to a clean wound it gives off formalin and keeps the wound aseptic. When it is applied to a sloughing surface it will not give off formalin unless it is mixed with pepsin and hydrochloric acid. Formalin-gelatin has been used to replace bone-defects.

Lysol is a clear, brownish, oily fluid with an odor like creasote. It is a valuable germicidal agent. It is saponified phenol and is used in a solution of a strength of from 1 to 3 per cent. It does not attack the hands like carbolic acid and is much less poisonous.

Mustard is an excellent emergency germicide. Its value has been demonstrated by Roswell Park, who uses a mixture of soap, cornmeal, and mustard flour to scrub the surgeon's hands or the patient's skin. I have used it repeatedly with entire satisfaction. Mustard removes the odor of decay at once.

Commercial gasolene is used by Riordan and others to clean wounds and ulcers, and to prepare the field of operation. Its vapor is so inflammable that the material must not be used when an artificial light is necessary, and it is used only in the daytime and on free surfaces where evaporation is rapid. It is sterile, non-irritant, and on evaporation leaves a dry, clean surface.

Tincture of iodin may be applied to an infected wound in the same manner as is pure carbolic acid; its use is advocated by Carl Beck. In dilute solution it is used to irrigate sinuses. The proper dilution for irrigation is obtained when the fluid is the color of sherry wine.

Nucleins, especially protonuclein, possess germicidal powers. Nuclein is composed of nucleinic acid and proteid material. When injected hypodermatically and to a less degree when taken by the mouth it increases the germicidal power of the blood-serum, causes leukocytosis and increased phagocytosis and thus prevents, or opposes infection. Mikulicz has used nucleinic acid to increase vital resistance as a preliminary to operation (page 40). A 1 per cent. solution of nucleinic acid is on the market. This acid is made from yeast. The dose of this preparation is from ♏x to ♏lx, hypodermatically, once or several times a day. *Protonuclein* probably contains nucleinic acid and is of some value when applied locally to areas of infection, particularly when sloughing exists.

Heat.—The best germicide is heat, and the best form in which to apply heat is by means of boiling water (even better than steam). One can use boiling water upon instruments and dressings, but rarely upon a patient. Jeannel, of Toulouse, uses boiling salt solution in abscess-cavities, and some other surgeons employ steam or boiling water to disinfect the medullary canal in osteomyelitis. Nevertheless, boiling water is rarely applied to the patient, and in many cases a chemical germicide must be used.

Among other antiseptics and germicides of more or less value we may mention trichlorid of iodin, chlorid of zinc, chlorid of iron, salol, oxycyanid of mercury, fluorid of sodium, argonin, sugar, lannaiol, bichlorid of palladium (in very dilute solution), thymol, potash soap, salicylic acid, boric acid, camphor, eucalyptol, cinnamon, bromin, chlorin (as gas or as chlorin-water), cinnamic acid, permanganate of potassium or of calcium, chlorate of potassium, and oxalic acid. The surgeon before operating should always scrub his hands in a germicidal solution.

Distribution of Bacteria.—Microbes are very widely distributed in nature. They are found in all water except that which comes from very deep springs; in all soil to the depth of three feet; and in air, except that of the desert, that over the open sea, and that of lofty mountains. Dust free air does not contain them; the more dust the more microbes, hence they are present in greatest number in the air of towns. There are more in narrow courts than in broad highways, more in crowded rooms than in uncrowded apartments. Bacteria are present on the skin, in the alimentary canal, in the nose, mouth, and pharynx and in the blood and lymph. As Adami points out under normal conditions the bacteria which enter the blood are very quickly killed.

Microbes may be be useful. Some of them are scavengers, and clean the surface of the earth of its dead by the process known as "putrefaction," in which complex organic matter is reduced to harmless gases and to a mineral condition. The gases are taken up from the air by vegetables, and the

mineral matter is dissolved in rain-water and passes into the soil from which it came, there again to be food for plants, which plants will become food for animals. Other organisms purify rivers; others cause bread to rise; still others give rise to fermentation in liquors. Microbes may be harmful. They may poison rivers and soils; they may be parasites on vegetable life; they cause diseases of the growing vine, and also of wine; they produce the mould on stale, damp bread; they occasionally form poisonous matter in sausages, in ice-cream, and in canned goods; and they produce many diseases among men and the lower animals.

With so universal a distribution of these *fungi*, man must constantly take them into his organism. They are upon the surface of his body, he inhales them with every breath, and he swallows them with his food and drink. Most of them, fortunately, are entirely harmless; others cannot act on the living tissues; but some are virulent, and these are generally, but not always, destroyed by the cells of the human body. The alimentary canal always contains bacteria of putrefaction, which act only upon the dead food, and not upon the living body; but when a man dies these organisms at once attack the tissues, and post-mortem putrefaction begins in the abdomen.

Koch's Circuit.—To prove that a microbe is the cause of a disease it must fulfil Koch's circuit. It must always be found associated with the disease; it must be capable of forming pure cultures outside the body; these cultures must be capable of reproducing the disease; and the microbe must again be found associated with the artificially produced morbid process.

Disease Production.—Pathogenic organisms cannot enter through the sound skin and the unbroken skin without causing the formation of lesions at the point of entrance. The sound skin is the very best antiseptic covering for tissue, as ordinary bacteria cannot pass it at all. Some bacteria by entering the ducts of cutaneous glands may cause disease. Disease-producing organisms which enter the body may reach the focus in which they act from outside of the body, entering by inoculation, inhalation, or ingestion. In most instances organisms which enter the body from without are rapidly destroyed. When they enter in large numbers, or when they are very virulent, or when the vital resistance of the individual is at a low ebb they cause disease. Bacteria may reach the region in which they become active from some other part of the body. Bacteria seldom dwell in the body long without inducing disease, but spores can lie dormant in the system for years. When bacteria or spores from some other part of the body reach a region of injury or disease they may become active; this area is a damaged and weakened part, in it the circulation is abnormal, it is a so-called point of least resistance (a *locus minoris resistentiæ*) which affords a nest for them to develop and to multiply, the cellular activities of the weakened part being unable to cope with the activities of the germs. Even large numbers of pathogenic organisms may induce no trouble in a healthy man; but let them reach a damaged spot, and mischief is apt to arise. Kocher established subcutaneous bone-injuries in dogs, and these injuries pursued a healthy course until the animal was fed upon putrid meat, whereupon suppuration took place. This experiment proves that micro-organisms can reach a damaged area by means of the blood, and it enables us to understand how a knee-joint can suppurate when we merely break up adhesions, and how osteomyelitis can follow trauma when the skin is intact. A given number

of organisms might produce no effect on a healthy man, whereas the same number might produce disease in an individual who was weak or ill-nourished, suffering from depression or fear, or debilitated by the habitual use of alcohol. The personal equation plays a great part in disease-production. Some individuals seem to be immune to certain diseases; and these immunities and liabilities may be hereditary or acquired, temporary or permanent.

Enzymes.—Bacteria contain and excrete ferments, and these ferments are known as enzymes. Bacterial ferments resemble pepsin and trypsin, the digestive ferments. The digestive ferments convert albumin into peptone, starch into sugar, and break up fat. When microbic infection of the tissues occurs the enzymes of the bacteria act upon the tissues just as the digestive ferments act upon the food, and form microbic albumoses. The enzymes are the weapons of micro-organisms. By means of these ferments bacteria not only prepare substances for assimilation, but seek to destroy antagonists and cell enemies. It is probable that enzymes when absorbed are frequently productive of toxemia.

Toxins.—The action of pathogenic bacteria upon the tissues is of great importance. In the first place, they abstract from the blood, the lymph, and the cells certain elements necessary to the body,—as water, oxygen, albumins, carbohydrates, etc.,—and thus cause body-wasting and exhaustion from want of food. In the second place, bacteria produce a vast number of compounds, some harmless and others highly poisonous. The symptoms of a microbic disease are largely due to the absorption of poisonous materials from the area of infection. These poisons may be formed from the tissues by the action upon them of the bacteria (true toxins and peptones) or may be liberated from the bodies of degenerating microbes (bacterial proteid or endotoxins). Bacteria contain and secrete ferments; and as albumoses are formed in the alimentary canal by the action of digestive ferments upon proteids, sugars, and starches, so microbic albumoses are formed by the action of microbic ferments upon tissues. Just as the albumoses formed in digestion are poisonous when injected, so the albumoses of microbic action are poisonous when absorbed. The albumoses of microbic action are called *toxalbumins*, and these albumoses often operate as virulent poisons to the body-cells.

A number of compounds formed by the microbic destruction of tissue are *alkaloidal* in nature. These poisonous alkaloids are readily diffusible and, many of them, very virulent. It is probable that every pathogenic organism has its own special toxin which produces its characteristic effects, although the effects are modified by the nature of the soil—that is to say, by the condition of the tissues. Again one micro-organism may produce several toxins. The absorption of toxins may be very rapid; for instance, the toxins of cholera may kill a man before the bacilli have migrated from the intestine. Brieger uses the term *toxin* to designate all of the poisonous products of bacterial action. He divides toxins into alkaloidal or crystallizable and amorphous, the latter being called toxalbumins.

Ptomaïns.—By many writers the term "ptomaïn" is used to designate these toxins, but in reality a ptomaïn is a form of toxin produced by the action of saprophytic bacteria. A ptomaïn is a putrefactive alkaloid, and a toxin is any poison of microbic origin. Among these putrefactive alkaloids may be mentioned tetanin, typhotoxin, sepsin, putrescin, tyrotoxicon, muscarin,

and spasmotoxin. The poison which occasionally forms in cheese, ice-cream, sausage, and canned goods is composed of ptomaïns. Poisoning by any putrid food is called ptomaïn-poisoning.

Leukomaïns must not be confounded with the above-mentioned bodies. Leukomaïns are alkaloidal substances existing normally in the tissues not produced by bacteria but arising from physiological fermentations or retrograde chemical changes. They are natural body-constituents, in contrast to toxins, which are morbid constituents. Leukomaïns are found in expired air, saliva, urine, feces, tissues, and the vemon of serpents. If not excreted, these bodies may induce illness, and when injected may act as poisons. Ordinary colds and some fevers result from leukomaïns; they play a great part in uremia, and when excretion is deficient the retained leukomaïns make the system a hospitable host for pathogenic bacteria. Sickness due to the retention and absorption of leukomaïns is known as *auto-intoxication*. Among leukomaïns may be mentioned adenin, hypoxanthin, and xanthin, allied to uric acid, and other substances allied to creatin and creatinin. The surgeon should never forget the possibility of harm being done by retained leukomaïns, and should endeavor to prevent autointoxication in all cases by keeping the skin, the bowels, and the kidneys active.

Immunity.—If a person cannot be infected with a certain disease, he is said to be immune. Some persons seem naturally immune to certain diseases. Immunity to some diseases may be produced artificially. It has long been known that when a person recovers from certain diseases he has become immune to the disease from which he suffered. Immunity may be transitory, prolonged or permanent. Acquired immunity may be compared to fermentation. When fermentation ceases, the addition of more ferment is without result. When a person recovers from certain diseases, the addition to his blood of more of the causative bacteria is also void of result.

Alexins and Antitoxins.—Immunity was long believed to arise from the exhaustion of some unknown constituent of tissue necessary to the life of the bacteria. This theory was advanced by Pasteur. It has been abandoned because of the demonstration that though an animal may be immune to certain bacteria, these bacteria will grow in its blood or tissue. A theory proposed by Chauveau is known as the "retention theory," and is the opposite of Pasteur's "exhaustion theory." According to Chauveau, bacteria growing within the body leave as a legacy excrementitious material, and the accumulation and retention of excrementitious products produce immunity.

At the present time there are two notable theories of immunity, and it is probable that each is at least partly true. The first theory is that of *phagocytosis*, which assumes that certain body-cells attack, consume, and destroy bacteria (see below). The other theory is founded on the discovery of Nuttal and Buchner that normal fresh blood-serum is germicidal, the power varying for different bacteria and being limited. A fixed amount of serum is capable of destroying a fixed number of bacteria of a certain variety. Vaughan and others have shown that the germicidal agent is probably a nuclein furnished chiefly by the white cells and held in solution by the alkaline serum. This germicidal agent Buchner called "*alexin*" or *defensive proteid*, and explained immunity by its presence. This theory is known as the "humoral theory." According to this theory, when an animal is naturally immune to a bacterial

disease it is assumed that the blood-serum and body-fluids contain enough of this alexin to dissolve or destroy the bacteria. In all probability both phagocytosis and bacterial solution are occurring in the same patient at the same time, phagocytosis being impossible but for the serum and bacteriolysis being impossible without leukocytes.

Since the above discoveries were made it has been found that when an animal recovers from some bacterial diseases the blood-serum and body-fluids contain a new protective substance which is not an alexin, but which has the power of destroying the toxins of the bacteria. It is known as an *antitoxin* and is produced by the body-cells under the stimulation of true soluble bacterial toxins. The first antitoxin to be discovered was that of diphtheria. The discovery was made by Behring in 1890. He found that if an animal is injected with gradually larger amounts of toxin of diphtheria the serum comes to contain an antitoxic material. Very soon after this discovery was announced Behring and Kitasato made a like discovery in regard to tetanus toxin. It is thus seen that bacteria not only produce poisons, but also stimulate the body-cells to produce antidotes to these poisons. Alexins exist in normal blood and kill bacteria. Antitoxins exist in blood of animals rendered immune and do not kill bacteria, but simply neutralize their toxins. An antitoxin combines with a toxin, and renders it inert and keeps it from combining with cells for which it has a special preference. It was pointed out by Kitasato and Behring that animals can be rendered immune to tetanus by artificial means and that the blood-serum of immune animals will, if injected into other animals, render them immune, or perhaps cure the disease if injected into animals suffering from tetanus. The same statements were also proved to be true of diphtheria. Now many experimenters are endeavoring to find the antitoxin of each microbic disease for the purpose of using it therapeutically and also as a preventive agent.

The real mechanism of antitoxin-formation is unknown, although it seems certain, as Roux maintains, that it is secreted by the body-cells.

Ehrlich's theory of the mechanism of immunity is at present attracting much interest. His theory may be explained in the words of D. H. Bergey ("American Medicine," Oct. 11, 1902).

"In the light of our later knowledge upon the subject, Ehrlich, in 1898, formulated his hypothesis of the mechanism of immunity which is receiving very general acceptance by scientists to-day. His theory of the mechanism of immunity is based upon Weigert's teaching of the process of tissue repair. It is a matter of universal observation that nature is prodigal in her attempts to repair an injury. This is shown in the healing process in an ordinary wound. A much larger amount of material is thrown out to bridge the chasm than is really utilized in the formation of new tissue. The presence of an excessive amount of new material is shown by the fact that the part is raised above the level of the surrounding sound tissue, and this excess is removed gradually as the new-formed tissue becomes stronger and stronger, until finally the wound is marked by a line of white scar-tissue, the excess gradually passing into the blood-current.

"Ehrlich believed that the mechanism of immunity was explainable on a similar basis. It had become evident from the experiments of Wasserman with the tetanus bacillus that its toxin had an especial affinity for the cells of the central nervous system. Experiments with other bacteria pointed to

the fact that the toxins of different species of bacteria had an especial affinity for the cells of different organs of the body. When the amount of poison entering the body is insufficient to destroy the cells which have an especial affinity for it, these cells may be injured only to such an extent as to permit subsequent repair. In order to comprehend Ehrlich's hypothesis it is necessary to conceive the cells of the body as having a complex structure which may be stated diagrammatically as consisting of a central mass or nucleus from which radiate a number of 'lateral chains,' or bonds, each of which serves to bind the cell to other substances. In the case of the cells of the central nervous system one of these lateral bonds has an especial affinity for tetanus toxin and suffers destruction. The cell now finds itself in unstable equilibrium, and at once proceeds to repair the damage wrought. As in the case of tissue repair, the new material produced is far in excess of the required amount. The excess finds its way into the blood-current. This material now circulating in the blood-current has the same affinity for tetanus toxin as when united with the central mass of a cell as its lateral bond, and can, therefore, combine with tetanus toxin floating in the blood-current, thus preserving other cells from injury. The union formed between the lateral bond of the cell (which is really the antitoxin) and the tetanus toxin results in the formation of a compound which is physiologically inert. According to Ehrlich's idea, therefore, the antitoxin is simply the excess of lateral bonds floating in the blood-current. This substance can neutralize the effect of the tetanus toxin in a test-tube just as readily as it does within the body."

In some infections soluble toxins are not formed and the body resistance depends largely on the formation by the bacteria of substances which finally, when present in sufficient amount, destroy bacteria.

Phagocytes.—It was generally believed after Metschnikoff's important discoveries that leukocytes were the agents which protected the body from infection. When other observers found that in blood-serum is material that damages or destroys bacteria, opinion swung to the view that the blood-serum contains the protective element, and that the leukocytes are simply scavengers and remove dead bacteria but do not destroy living ones. It has recently been shown that under some circumstances leukocytes destroy living bacteria and under other circumstances they do not and that the presence or absence of this property depends upon the presence or absence in the blood-serum of substances which act upon bacteria and render them susceptible to the phagocytic action of leukocytes. The existence of these substances was demonstrated by Wright and Douglas in 1903, and they named them *opsonins*. If opsonins are present, they act upon bacteria, and render the bacteria susceptible to phagocytosis. (See Ludvig Hektoen in "Jr. Am. Med. Assoc.," May 12, 1906.) The source of opsonins is not known but serum normally contains "opsonins for many different bacteria" (Hektoen, in "Jr. Am. Med. Assoc.," May 12, 1906). When experiment determines the fact that an individual's leukocytes are highly phagocytic toward particular bacteria, we believe that a quantity of opsonin for that variety of bacteria is present, and we may say the individual has a high *opsonic index* as regards them. Under opposite condition we say he has a low opsonic index. The tendency of the white blood-cells, and in a less degree of the endothelial cells of the blood-vessels, lymph-spaces, and lymph-channels, to destroy bacteria under certain circumstances is undoubted.

This process of destruction is known as *phagocytosis*, and the destroying cells are called *phagocytes*. When infection occurs, the white blood-cells gather in enormous numbers at the seat of disease, encompass and surround the bacteria, and build a barrier to prevent dissemination of the microbes and general infection of the organism. The force which draws leukocytes to a region of infection also tends to draw them to an area where there is cellular degeneration or death. This force is called positive chemiotaxis and is greatly stimulated by opsonins. In very virulent infections the leukocytes may fail to collect and may actually be repelled and scattered under the influence of what has been called negative chemiotaxis. Phagocytes at the seat of infection try to eat up, carry away to a gland, and there digest and destroy bacteria. A battle royal occurs, the microbes fighting the body-cells with most active ferments and destroying the opsonic power of the blood-liquor; the body-cells endeavoring to devour and destroy the bacteria (Fig. 14), in which effort opsonins give them aid. In some cases the bacteria win absolutely and the patient dies. In other cases they win for a time and overwhelm the system; but presently the body-cells, whose movements were inhibited by the poison, regain their activity and are now immune to the bacterial poison. It is probable that the materials thrown out by the white cells during the combat with the microbes tend to destroy bacterial products and to neutralize toxic products of tissue destruction. These materials, which neutralize toxic products are known as *antitoxins* (page 36). After the attack of disease has passed away the body-cells have been educated to withstand this poison, and new cells in the future retain this capacity; the weak cells were killed, the fittest survived, and the body fluids contain antitoxin. The new cells formed in the body are insusceptible to the poison and the individual is said to be *insusceptible* or *immune*. The theory of phagocytosis immunity assumes an educated white corpuscle and body-cell. This view originated with Sternberg, but it is usually accredited to Metschnikoff. Lankester gave us the term "educated corpuscle."

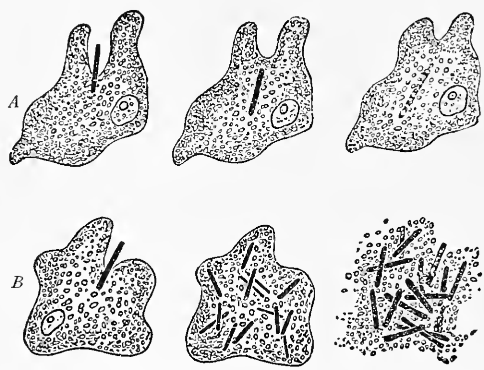


Fig. 14.—Phagocytosis: *A*, Successful; *B*, Unsuccessful (Senn).

Artificial Stimulation of Phagocytosis.—When active hyperemia is induced by heat, when irritants are applied to an inflamed surface, or when an inflamed joint is treated by Bier's method of passive hyperemia, local leukocytosis is stimulated and phagocytosis becomes more active. Some ten years ago Issaeff affirmed that the introduction of certain materials, as salt solution, into the peritoneal cavity, leads, for a time, to great increase in the resistance to abdominal infection. This period of increased resistance he called the *resistance period*. It begins a few hours after the injection and terminates by the end of the fifth day. During this period the great increase in intra-

peritoneal leukocytes saves the animal from infection with bacteria which would otherwise cause a dangerous or fatal inflammation. Mikulicz believed it possible to establish this resistance period before abdominal operations and was working on the problem just before his lamented death. Mikulicz used diluted nucleinic acid (Mikulicz, "Verhandl. d. 33. Congress d. Deutsch. Ges f. Chir.," 1904). The agents used must not be of a nature to damage opsonins, for leukocytosis without plenty of opsonins would do no good.

Vital Resistance.—It is learned from the above that the vital resistance to infection depends in part upon germicidal and opsonic blood-liquor and in part upon active leukocytes.

Vital resistance is increased by agents which cause active phagocytosis (see nucleinic acid, page 33) without destruction of opsonins.

Anything that lessens the germicidal and opsonic power of blood-serum or the phagocytic activity of corpuscles lessens vital resistance. Among these causes are ill health, worry, unhygienic life, chronic drug intoxications, chronic visceral diseases, diabetes, Bright's disease, gout, rheumatism, violent and sudden fluctuations of temperature, and the creation of points of least resistance (page 34).

Protective and Preventive Inoculations.—Our knowledge of protective inoculations for contagious diseases dates from Jenner's discovery of vaccination against smallpox in 1798. Preventive inoculations with attenuated virus are due to the experiments of Pasteur. This observer discovered the cause of chicken-cholera, and cultivated the micro-organism of this disease outside the body. He found that by keeping his cultures for some time they became attenuated in virulence, and that these attenuated cultures, inoculated in fowls, caused a mild attack of the disease, which attack was protective, and rendered the fowl immune to the most virulent cultures. Cultures can be attenuated by keeping them for some time, by exposing them for a short period to a temperature just below that necessary to kill the organisms, or by treating them with certain antiseptics. It has further been shown that injection of the blood-serum of an animal rendered immune by inoculation is capable of making a susceptible animal also immune.

A most important fact is that animals may be rendered immune to certain diseases by inoculating them with filtered cultures of the microbes of the disease, the filtrate containing microbic products, but not living microbes. By this method animals can be rendered immune to tetanus and diphtheria. Pasteur's protective inoculations against hydrophobia owe their power to microbic products, and Koch's lymph contains them as its active ingredients. The chief feature in acquired immunity is the presence in the blood and tissues of elements which can neutralize the toxic products of bacteria. These elements are "antitoxins" (page 36). Microbic products are dead and cannot multiply as can living bacteria, hence the human organism is not overwhelmed unless the dose is too large, but the microbic products cause the development of antitoxin as certainly as do the living microbes. The above facts are of immense importance, for on these lines may be solved the problems of the prevention and treatment of microbic maladies.

Orrhotherapy, or **serum-therapy,** is an attempt to utilize therapeutically the germicidal properties of blood-serum. It is believed that when a person recovers from an infectious disease the alkaline blood-serum is

saturated with protective material known as antitoxin. If this belief is true, it is a proper deduction that blood-serum containing protective material should cure the disease if injected into a patient suffering from an attack. Instead of using the blood-serum itself, some observers have precipitated the supposed curative material from the serum, have dissolved this material, and have administered the solution in fixed amounts. Instead of using the serum of persons rendered immune by an attack of the disease, many physicians have employed the serum of animals rendered artificially immune by injections of attenuated cultures of the bacteria or injections of bacterial products. Some experimenters have even employed the serum of animals naturally immune to the disease. In some cases the serum is given hypodermatically, in some intravenously, in some by lumbar puncture, in some by intracerebral, and in others by intraneural injection. That Pasteur has devised a method which will usually prevent hydrophobia is certain (page 270), and that Murri, of Bologna, has cured a case of hydrophobia seems proved (page 271). Hosts of observers believe in the utility of tetanus antitoxin and diphtheria antitoxin. The earlier in the disease the injection of antitoxin is practiced and the larger the dose the more apt it is to prove curative. When the toxin has not yet combined with cells antitoxin may keep it from doing so, and when it has recently combined and the combination is still unstable, antitoxin may cause disassociation of the combination. When the disease is well established the cell combination of toxin is firm and antitoxin will in all probability fail to cure.

Inconclusive experiments have been made in the treatment of syphilis by the serum of dog's blood, and by the blood-serum of men laboring under tertiary syphilis; in the treatment of pneumonia with the blood-serum of persons convalescent from pneumonia; and in the treatment of sufferers from septic diseases with antistreptococcic serum—blood-serum of animals rendered immune to septic infections. The real value of antistreptococcic serum is as yet uncertain. Occasionally it seems to do great good; at other times it appears to produce no benefit whatever. In several cases of phlegmonous erysipelas and in two cases of malignant endocarditis I thought it was of benefit. Tavel, in a recent elaborate research ("Klinische-therapeutische Wochenschrift" (Vienna), August, 1902), states that he obtained brilliant results in some cases, but no results in others. He does not undertake to explain this variability of action. He thinks the serum benefits staphylococcus as well as streptococcus infections. Malignant tumors (both sarcomata and carcinomata) have been treated with the blood-serum of dogs, which animals had been injected with fluid expressed from malignant growths (Richet and Hericourt). Von Leyden and Blumenthal obtain a serum by compression of a recent cancerous growth and treat human victims of cancer with it. They claim that the results are encouraging ("Deutsche medicinishe Wochenschrift," Sept. 4, 1902). Many claims made for serum-therapy in surgical diseases are exaggerated, sensational, and unscientific. It does not seem possible to obtain an antitoxin for each bacterial malady and the bacteria of most specific diseases are potent for harm for more reasons than because they form crystalloidal toxic matter. That there is truth in the method seems highly probable, but how much truth there is, is not yet definitely ascertained. It is our duty to study, experiment, and observe, and to reach a conclusion

only after honest, careful, and thorough investigation. A little skepticism is as yet a safe rule.

Special Surgical Microbes.—Suppuration (see page 127).—Suppuration is caused by microbes. Does it ever exist without them? The answer is, "Practically no." Injection of a sterile fluid containing dead organisms, or the injection of the sterile products of the growth of pyogenic cocci, will form a limited amount of pus; injection of an irritant forms a thin fluid which may resemble pus, but which is not pus. In surgery pus is very seldom met with without the actual presence of micro-organisms (page 128), and the presence of pus proves the presence of micro-organisms.

Pyogenic Bacteria.—*Pus microbes*, or *pyogenic microbes*, are strongly proteolytic, that is, they possess the property of peptonizing albumin, and thus forming pus. The peptonizing action is brought about by bacterial products. Some believe that pus is not formed by a peptonizing action of the bacteria but that the bacteria furnish a poison (leukolysin) which breaks up the leukocytes, and that the breaking up of leukocytes liberates an enzyme which dissolves albumin. The inflammation which surrounds an area of pyogenic infection is caused by the irritant products of bacterial action (tox-albumins, ammonia, etc.). In the presence of the pyogenic peptones the coagulation of inflammatory exudate is retarded or prevented. Bacteria which ordinarily cause suppuration may not cause it but produce non-suppurative inflammation if they are present in small numbers or if the tissue resistance is at a high level, or if their virulence has been modified by adverse antecedent conditions. Bacteria which ordinarily do not cause suppuration may do so under certain conditions of increased bacterial virulence or lessened tissue resistance. The typhoid bacillus is at times pyogenic, but, as a rule, it is not pyogenic. The usual causes of suppuration are the following micro-organisms.

The term *micrococcus pyogenes* (Fig. 15) includes the staphylococcus aureus, the staphylococcus albus, and the staphylococcus citreus. These forms are deviations from one form and are not specifically different. The albus and citreus may be grown from the aureus and they may remain white and yellow or may revert in part to the aureus form ("Atlas of Bacteriology," by Lehmann and Neumann). Some observers maintain that these forms vary greatly in virulence and hence are specifically different, but the varying virulence has been disputed and it seems to have been proved that virulence may be lessened greatly even when the color does not change. Seventy-seven per cent. of acute abscesses are due to staphylococci (W. Watson Cheyne). Staphylococci are found also in osteomyelitis, in a carbuncle, in a boil, in acne, in pemphigus, in periostitis, in septicemia, and in pyemia, and in some cases of empyema and peritonitis.

Staphylococcus pyogenes aureus (Plate 1, Fig. 1, and Fig. 15), the golden-yellow coccus. When grown in the air it produces orange-yellow pigment. This is the most usual cause of abscesses (circumscribed suppurations). The staphylococcus pyogenes aureus grows best in air but can grow when air is excluded. As it can thus grow it is a facultative, aërobic parasite. It is widely distributed in nature, and is found in the soil, the dust of air, water, the alimentary canal, under the nails, on and in the superficial layers of skin, especially in the axillæ and perineum, in the mouth, the nasal cavities, the

vagina, and human milk. It forms the characteristic color only when it grows in air (Plate 1, Fig. 1). It is killed in ten minutes by a moist temperature of 58° C., and is instantly killed by boiling water. Carbolic acid (1 : 40) and corrosive sublimate (1 : 2000) are quickly fatal to this coccus.

Staphylococcus pyogenes albus (Plate 1, Fig. 2), the white staphylococcus, acts like the aureus, but is usually more feeble in power. When this organism is found upon and in the skin it is called the *staphylococcus epidermidis albus*, an organism which Welch proved to be the usual cause of stitch-abscesses.

Staphylococcus pyogenes citreus, the lemon-yellow coccus, is found occasionally in acute circumscribed suppurations, but less often than are the other two forms. Its pyogenic power is even weaker than that of the albus.

The *staphylococcus cereus albus* and the *staphylococcus cereus flavus* are found occasionally in acute abscesses, but these forms cannot be sharply differentiated from the micrococcus pyogenes and the names should be abandoned.

Staphylococcus flavescens is occasionally found in abscesses. It is intermediate between the aureus and albus (Senn).

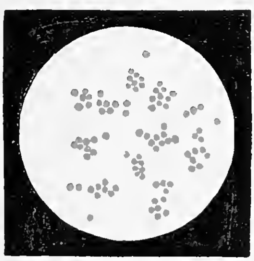


Fig. 15.—Micrococcus pyogenes aureus (× 1000). (Lehmann and Neumann.)

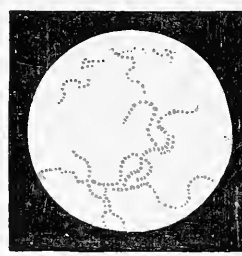


Fig. 16.—Streptococcus pyogenes (× 700). (Lehmann and Neumann.)

Micrococcus pyogenes tenuis rarely takes the form of a bunch of grapes. It is occasionally found in the pus of acute abscesses.

The *micrococcus tetragenus* is thought to be the bacterium chiefly responsible for the suppuration of tuberculous pulmonary lesions.

Streptococcus Pyogenes (Fig. 16).—This coccus, known as the chain coccus, grows best in air and can also grow when air is excluded. It is found in the healthy human body in the nasal cavities, urethra, mouth, vagina, and on the skin. It causes spreading inflammation and suppuration, erysipelas, pneumonia, puerperal fever, pyemia, septicemia, lymphangitis, some very acute abscesses, and some cases of meningitis, empyema, peritonitis, pericarditis, osteomyelitis, and diarrhea. It varies very greatly in virulence and the intensity of its action is strongly influenced by the nature of the soil in which it is implanted. Not only do streptococci produce virulent toxins, but they also produce a non-toxic material called hemolysin, which dissolves red corpuscles. Woodhead tells us (Treves' "System of Surgery") that six organisms, each of which bears a separate name, are discussed under this designation. Three of these organisms he places in one group, two in another, and says the sixth may be a separate species.

1st Group.—*Streptococcus pyogenes* (Fig. 16), found especially in spreading suppuration. Such suppurations spread because streptococci only feebly attract leukocytes and also prevent the coagulation of exudate. Streptococci are also found in very acute abscesses. Cheyne says that 16 per cent. of acute abscesses contain streptococci. The streptococcus pyogenes is easily killed by boiling, and can be destroyed by carbolic acid and corrosive sublimate. These organisms are normally present in the nasal passages, vagina, mouth, and urethra.

Streptococcus pyogenes malignus, an uncommon organism found in splenic abscess.

Streptococcus septicus has a strong tendency to break up into diplococci.

2d Group.—*Streptococcus of erysipelas* is found in the capillary lymph-spaces in erysipelas. Many bacteriologists believe it to be identical with the streptococcus pyogenes. These bacteria tend particularly to gather in the lymph-spaces. They rarely produce pus and when they do it is usually watery. When ordinary thick pus forms there is a mixed infection with staphylococci.

Streptococcus of Septicemia and Pyemia.—Most observers maintain that it is identical with the streptococcus pyogenes and the streptococcus of erysipelas.

3d Group.—*Streptococcus articulorum*, found in the false membrane of diphtheria (see the article by Woodhead in the "System of Surgery" by Sir Frederick Treves).

Other Pyogenic Organisms.—The various forms of colon bacillus, the typhoid bacillus, the streptococcus intracellulosis, and the pneumococcus, are at times pyogenic. A common form of colon bacillus is the bacillus pyogenes fetidus: it is found in stinking peritoneal pus and in the pus of ischio-rectal abscesses. The gonococcus is also pyogenic. Blue pus is produced by the bacillus pyocyaneus (Ernst).

The bacillus pyocyaneus forms chains and may produce suppuration itself. Usually, however, when it appears it constitutes a secondary infection in a suppurating area. It causes a blue or blue-green hue in pus and wound discharges.

It is normally found in water and exists in the mouth, intestine, and in the skin.

Other Surgical Microbes.—*Streptococcus of erysipelas* (Fehleisen's coccus), as stated before, is thought by many to be identical with the streptococcus pyogenes. Their difference in action is believed by Sternberg to be due to difference in virulence induced by external conditions and by the state of the tissues of the host. The coccus of erysipelas is somewhat larger than the ordinary form of streptococcus pyogenes. Infection takes place by a wound, often a very trivial wound of the skin or mucous membrane. The cocci multiply in the small lymph-channels. This coccus will cause puerperal fever in a woman in childbed when it gains access to "an absorbing surface in the genital tract" (Senn). The streptococcus may cause suppuration in erysipelas, mixed infection not being necessary to induce pus-formation.

The *gonococcus*, or the *micrococcus gonorrhϾ* (the bacillus of Neisser) (Fig. 18), is the diplococcus which causes gonorrhea. Bumm proved the causative influence of the gonococcus. He reproduced the disease in a healthy female urethra by inoculation with the twentieth generation in descent from a

1 2 3

1. Staphylococcus pyogenes aureus.
2. Staphylococcus pyogenes albus.
3. Bacillus tuberculosis on glycerin-agar.

(Warren's *Surgical Pathology*.)

pure culture. These diplococci are in pairs and each member of a pair is kidney-shaped (Fig. 17). Gonococci grow best in air but can grow when air is excluded (facultative aërobic). Diplococci are found often in the secretions of apparently healthy mucous membranes, and simulate very closely gonococci, but genuine gonococci are not so found. Neither are gonococci found outside of the organism except upon articles contaminated with gonorrheal discharge. In male gonorrhea the gonococci are in the urethra and prostate; in female gonorrhea they are in the urethra, glands of Bartholin, and cervix uteri. These cocci may cause gonorrheal conjunctivitis, lymphangitis, lymphadenitis, rhinitis, otitis, proctitis, endometritis, salpingitis, oöphoritis, cystitis, peritonitis, bursitis, thecitis, pleuritis, malignant endocarditis, arthritis, periostitis, abscess, and parotitis. In chronic urethral gonorrhea the gonococci may at times be absent from the discharge, returning when there has been sexual or alcoholic excess, traumatism, or contact with an irritant secretion. In such a case a very few gonococci must have multiplied and the majority of the bacteria must have quickly died so that there were never many in the urethra at one time, and the discharge must have been kept up by their irritant toxins. If a part in such a condition is irritated active multiplication begins and the cocci reappear in the discharge. Gonococci cannot be cultivated upon ordinary media but grow best upon human blood or human blood-serum. In gonorrhea the organisms are found both within and outside of pus-cells and on mucous-cells (Fig. 18). The gonococci infect a surface covered with cylindrical epithelium much more readily than a surface covered with pavement epithelium. They pass into the submucous tissue, cause inflammation, and spread by way of the lymph paths. It seems certain

Fig. 17.—Micrococci gonorrhœæ, highly magnified, schematic. (Lehmann and Neumann.)

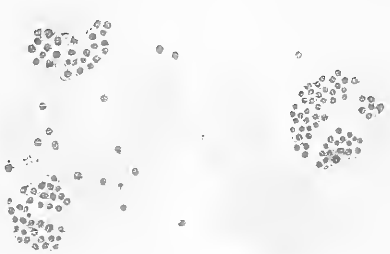


Fig. 18.—Gonococci from gonorrheal pus.

that the gonococcus is pyogenic, although mixed infection with other pyogenic organisms may exist in this disease. Their presence inside of pus-cells means phagocytosis. Gonococci stain easily by methylene-blue and are readily decolorized by Gram's method.

In noma *streptococci* are found. No specific organism has been isolated for traumatic spreading gangrene or hospital gangrene.

The *Bacillus of tetanus* or the *bacillus tetani* (Nicolaier's bacillus) (Fig. 19), is an anaërobic parasitic organism. In recent cultures at least it ceases to grow in the presence of oxygen and grows within the tissues of the animal

body. In a wound to which air has access the bacilli may lie so surrounded by fluid that air is excluded. Pyogenic or saprophytic bacteria may consume the air or the bacilli may lie in a laceration of the tissue the outlet of which is sealed by exudate or blood. It is a facultative saprophyte, that is, under certain conditions it can grow in dead organic material. It is possible to develop by cultivation bacilli which will live in air.

The bacilli of tetanus are widely distributed. They are found in hay, in the soil of gardens, in the dust of old buildings, in street dust and dirt, and in the sweepings of stables. The feces of healthy horses, cattle, and men may contain the bacilli. Tetanus develops after a wound and the bacilli remain in the wound and do not enter the blood. They furnish deadly toxins which are absorbed. The symptoms are due to intoxication not to infection. The toxin of tetanus is alkaloidal not albuminoid. These bacilli stain by Gram's

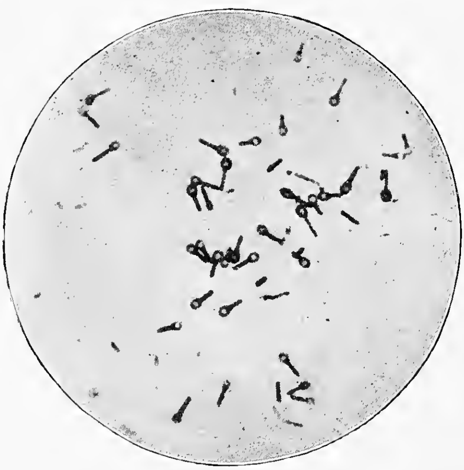


Fig. 19.—Bacillus of tetanus, with spores.

method. Cultures are made on sugar-agar plates, the air being excluded. These bacilli when placed under somewhat unfavorable conditions sporulate with great rapidity, and the spores are seen at the ends (Fig. 19). The spores are far more resistant than the adult bacilli, and it is difficult to kill them in a wound. The drug which is most certainly fatal to tetanus bacilli is bromin.

The *Bacillus tuberculosis* (Koch's bacillus) (Fig. 20). This bacillus is the cause of all tuberculous processes.

It is non-motile and requires oxygen in order to grow but may obtain this from the body-cells or fluids. It stains by Gram's method and by fuchsin. These bacilli are cultivated upon glycerin agar or solid blood-serum (Plate 1, Fig. 3). They are found in dust containing the dried sputum of victims of phthisis and dried discharges and secretions of tuberculous patients. This infected dusty air is the chief means of conveying infection (inhalation tuberculosis). Infection can also be conveyed by inoculation of bacilli (inoculation tuberculosis) and by eating the meat and drinking the milk of tuberculous animals (ingestion tuberculosis). Tuberculin is discussed on page 218.

Bacillus anthracis or the *bacillus of anthrax* (Fig. 21) is the cause of

malignant pustule, or splenic fever. It is non-motile. Tissue containing it is stained by Gram's method. Cover-glass preparations are stained with a watery solution of an anilin dye. It will grow without oxygen but grows best in air. In the presence of air sporulation occurs but it does not occur in the infected animal. It grows upon or in gelatin or agar. Outside of the diseased body only the spores are found and they exist in the hides and hair of infected animals and in stalls and pastures in which diseased animals were kept.

Fig. 20.—Tubercle bacilli in sputum (Ziegler).

Bacillus mallei or the *bacillus of glanders* is the cause of glanders. It is non-motile and grows best in air and grows with great difficulty when air is excluded. It grows well upon glycerin agar, and does not stain by Gram's method. It is never found except in the body of a diseased man or other animal. It is best cultivated in solid blood-serum. Under certain circumstances some few of the bacilli contain spores.

The *Pneumococcus*, called also the *diplococcus pneumoniæ*, *Fränkel's bacillus*, and the *streptococcus lanceolatus*, is often found in the saliva of healthy in-

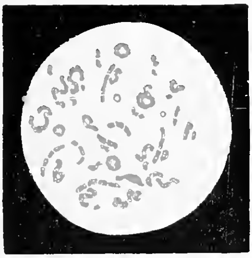


Fig. 21.—Bacillus anthracis (× 1000). (Lehmann and Neumann.)

Fig. 22.—Bacillus of malignant edema (Lehmann and Neumann).

dividuals. It is not found outside the body. It varies greatly in virulence but when virulent can establish inflammation and even suppuration particularly of mucous and serous surfaces. It may cause croupous pneumonia, catarrhal pneumonia, pleuritis, meningitis, conjunctivitis, arthritis, peritonitis, periostitis, osteomyelitis, parotitis, salpingitis, perinephric and other abscesses, nephritis, tonsillitis, and septicemia. In any of these conditions it may appear in the blood. It grows best in bouillon cultures and in ascites glycerin agar.

The *Bacillus coli communis*, called also the *bacterium coli commune*, the *colon bacillus*, or the *bacillus of Escherich* (Fig. 23). Under ordinary conditions this is a putrefactive bacillus inhabiting the intestinal canal and feces invariably contain it. It is found in the mouth, nose, and vagina, on the skin and under the nails. The bacillus is normally found in water, even in water regarded by the users as pure. It has already been stated that this ordinarily harmless organism may, under certain conditions, acquire pathogenic power and enter the circulation. This bacterium grows best in air but it can also grow when air is excluded. It is not stained by Gram's method, and has pyogenic power. It stains with anilin, dies, and is decolorized by iodin solution. There are numerous forms of colon bacilli, and some of them are motile, some are amotile. This bacillus may be responsible for appendicitis, peritonitis, inflammation of the genito-urinary tract, pneumonia, inflammation of the intestine, leptomeningitis, perirenal abscess, cholangitis, cholecystitis, myelitis, puerperal fever, wound infection, and septicemia. It is the cause of many abscesses about the intestine, and is responsible for many ischiorectal abscesses. From the pus of an appendiceal abscess we may perhaps obtain a pure culture of Escherich's bacillus, but usually find also streptococci, staphylococci, or pneumococci.

The Spirochæta Pallida.—A bacterial cause of syphilis has long been sought for. Lustgarten thought he had found it in a bacillus resembling the tubercle bacillus, but this view has not been proved. Schaudinn and Hoffmann have described an organism constantly present in the initial lesion of syphilis and in secondary lesions and which they call the spirochæta pallida ("Arbeiten aus dem Kaiserlichen gesundheitsamte," Berlin, April 10th, Heft 2). These organisms are found in great numbers in the juice of syphilitic glands, in condylomata, and in chancres. They are motile, are without flagella, curve from 3 to 12 times, and are stained with difficulty. Rosenberger considers it to be a protozoön and to belong with the animal parasites. The spirochæta was originally discovered by Bordet and Geugm in 1903. These observers found them in chancres but thought their presence was inconstant, Schaudinn and Hoffmann show that it is constant. Many observers believe it is the cause of syphilis. Rosenberger says "that it plays some part in the etiology of syphilis seems plausible, as it has not been encountered except by one or two observers in any other lesion than syphilis" ("Am. Jour. Med. Sciences," Jan., 1906).

The *Bacillus œdematis maligni*, the *bacillus of malignant edema* or the *vibrione septique* of Pasteur (Fig. 22). This bacillus is found especially in stagnant water and certain varieties of soil and exists in putrefying material. It is sometimes motile but is often amotile and multiplies by spore formation. It is anaërobic and in its growth produces bubbles of gas. In the disease known as malignant edema there is usually a mixed infection with the bacilli of malignant edema and saprophytic organisms, and the latter also form considerable quantities of gas in the tissues. The bacilli of malignant edema may cause either spreading bloody edema containing gas bubbles or spreading emphysematous gangrene. The bacilli enter the blood and produce septicemia. The bacillus is grown in the interior of a stab in gelatin agar-agar or solid blood-serum when the mouth of the stab has been sealed up.

The Bacillus Aërogenes Capsulatus of Welch.—This bacillus is found some-

times in abscesses containing gas. It is causative of some cases of gangrenous cellulitis which is a spreading gangrene with gas formation.

This bacillus has a capsule and very seldom forms spores. It stains by Gram's method and grows well upon blood-serum.

As pointed out by Lehmann and Neumann there are occasionally encountered "gaseous phlegmons and similar diseases of internal organs, in which are found the bacterium coli alone or usually in combination with other varieties, but without any anaërobes being present ("Atlas and Principles of Bacteriology," Vol. II, edited by Geo. H. Weaver).

The *Bacterium typhi*, the typhoid bacillus, or Eberth's bacillus, is sometimes found in water or soil contaminated by typhoid fecal matter. It never exists in the healthy human body. It causes typhoid fever and in this disease can be obtained and cultivated particularly from the spleen and lymphatic glands and frequently from the blood. It has been found in urine, kidney, bone marrow, and bile. It is difficult to cultivate typhoid bacilli from feces because of the presence of multitudes of other bacteria. The bacillus of typhoid

Fig. 23.—Bacillus coli communis.

is motile, does not stain by Gram's method, and grows best in air but can grow when air is excluded. It grows upon all the ordinary nutrient media. This bacillus is particularly apt to be confounded with the colon bacillus, and it is even possible that the former develops from the latter. Besides typhoid fever the typhoid bacillus may cause peritonitis, chronic osteomyelitis, gangrene, cholecystitis, thrombosis, embolism, synovitis, and arthritis. This bacillus, under certain conditions, is pyogenic. Typhoid bacilli are agglutinated and lose motion by contact with a 1 to 50 dilution of the blood-serum of a patient with typhoid fever or convalescent from typhoid fever (the Widal reaction).

Putrefactive Bacteria.—By putrefaction we mean the decomposition of albuminous matter with the production of materials possessed of a foul odor. The bacilli of putrefaction act upon dead tissue exposed to air and are most active when the supply of air is somewhat limited. The surgeon encounters these bacteria in areas of necrosis or in tissues previously destroyed by other microbes. In the latter case they cause a mixed infection. An instance of such a mixed infection is putrid pus. Some of the products of putrefactive bac-

teria are highly poisonous (ptomaïns). Absorption of a small amount of putrid toxin causes surgical fever and absorption of a large amount causes putrid intoxication.

The chief putrefactive alkaloids are: The colon bacillus (when under normal conditions); the bacillus of malignant edema; the proteus vulgaris; the proteus mirabilis; the three forms of the bacillus saprogenes; and the proteus Zenkeri.

We may mention, in conclusion, as of occasional surgical importance, the bacillus of influenza, bacillus of diphtheria, bacillus of bubonic plague, bacillus of leprosy, bacillus of rhinoscleroma, bacillus of fetid ozena, bacillus of hemorrhagic septicemia, and bacillus lactis aërogenes, which is an unusual cause of peritonitis.

The *ray-fungus* is considered on page 272.

Infections with Protozoa.—Protozoa is the name given to the lowest forms of animal life. This group of organisms shows transitions from forms certainly animal toward forms certainly vegetable. The protozoa are minute unicellular organisms. The cell has a definite nucleus and is composed of protoplasm and a more or less dense cell-wall. Many species have organs of locomotion (cilia or flagella). Protozoa are known to cause malaria (the plasmodium malariæ) and tropical dysentery (the entameba histolytica). Some observers maintain that they cause cancer, and it is thought probable that they may produce smallpox, yellow fever, scarlatina, and spotted fever.

II. ASEPSIS AND ANTISEPSIS.

The effort in all operations is to secure and maintain scrupulous surgical cleanliness. What is known as the antiseptic method we owe to the splendid labors of Lord Lister, and the aseptic method is but a natural evolution of the antiseptic method. It is true that Agostino Bassi, over half a century ago, convinced that various maladies were due to parasites, treated wounds with a solution of corrosive sublimate. It is also true that Semmelweis in 1847 demonstrated the infectiousness of puerperal fever and the method of preventing it; that Jules Lemaire in 1863 published a treatise on carbolic acid and advocated the use of this drug in the treatment of wounds in order to destroy living germs, and that Bottini in 1866 employed carbolic acid in the treatment of putrid and suppurating wounds because he believed germs to be responsible for such conditions (Monti on "Modern Pathology"). In spite of the above facts, Lister is the real father of asepsis and taught all nations how to prevent infection. Monti says: "But Lister, with that practical spirit which forms one of the best characteristics of English genius, from the scientific studies of Pasteur, deduced the general laws of antisepsis and the rules for their methodical application to practical surgery." Lister called the attention of the profession to a new method of treating wounds, compound fractures, and abscesses in 1867.* The processes first employed were extremely complicated, but have been made in the last few years simple and easy of performance. Lister believed the chief danger to be from air. It is now believed that the chief danger is from actual contact of hands, instruments, dressings,

* The Lancet.

or foreign bodies with a wound. Air carries but few micro-organisms unless it is filled with dust. Infection through air is most apt to occur if the air is dusty, and is more common after an aseptic than an antiseptic operation.

Of course, some bacteria from the air must settle in every wound, but the majority of air fungi are harmless. Comparatively few reach the wound unless the air is dusty, and these few the tissues are usually able to destroy. Schimmelbusch made experiments in v. Bergmann's clinic when the students were present. He found that "the number of bacteria which settle upon the surface of a wound a square decimeter in extent, in the course of half an hour, is about 60 or 70," and thousands are usually required to produce infection.

There is no danger of the breath alone producing infection. Air which comes from the lungs is germ-free, and even a large class will not infect the air by breathing, but will rather help free it from bacteria, for the lungs are filters for air laden with micro-organisms.

In performing any surgical operation cutting is better than tearing by blunt dissection. The former method makes an incised wound, the latter a lacerated wound. In an incised wound there is a minimum amount of damage and rapid repair. In a lacerated wound some necrosis occurs and there is great lowering of tissue resistance, hence a lacerated wound is much more apt to become infected than is an incised wound.

Surgical cleanliness may be obtained by either the *aseptic* or the *antiseptic* method. In the *aseptic method* heat, chemical germicides, or both are used to cleanse the instruments, the field of operation, and the hands of the surgeon and his assistants, the surface being freed from the chemical germicide by washing with boiled water or with saline solution. After the incision has been made no chemical germicide is used, the wound being simply sponged with gauze sterilized by heat; if irrigation is necessary, boiled water or normal salt solution is used, and the wound is dressed with gauze which has been rendered sterile by heat. The effort of the surgeon is simply to prevent the entrance of micro-organisms into the tissues. Some micro-organisms must enter, but the number will be so small that healthy tissues will destroy them. The aseptic method should be used only in non-infected areas. If chemical germicides are not used, there will be a minimum amount of irritation, few cells will be destroyed, the amount of wound-fluid will be small, the surgeon can often dispense with drainage, and repair will be rapid. If a wound is to be closed without drainage, every point of bleeding must be ligated. Many wounds are closed by interrupted through-and-through sutures. Some wounds are closed in layers. If a wound is closed in layers, muscle being against muscle, fascia against fascia, etc., the skin may be closed by interrupted sutures or by Halsted's subcuticular stitch. If this stitch is employed, the skin staphylococcus does not obtain access to stitch-holes, and stitch-abscesses are not apt to arise. This suture may consist of catgut, silk, or, preferably, silver wire, this latter agent being capable of certain sterilization by heat and exercising a powerful inhibitory action on micro-organisms. If a wound is closed without drainage, firm compression is applied over the wound to obliterate any cavity which may exist. Such a cavity is called a *dead-space*. If a dead-space is allowed to remain wound-fluid will gather, tissue resistance will be lowered, and the wound-fluid, the tissue, or both, may become infected.

Drainage must be used if the wound is very large, if its shape or structure prevents the obliteration of the cavity by pressure, if there is any doubt as to the perfect cleanliness of the part, if the patient is very fat, for in such individuals fat necrosis predisposes to sepsis and to fat embolism, and if the skin is so thin that we fear pressure will produce sloughing ("A Manual of Surgical Treatment," by Cheyne and Burghard). In some regions of the body wounds are sealed with collodion or iodoform-collodion. If irrigation is not practiced and the wound is dressed with dry sterile gauze, the procedure is said to be by the *"dry" aseptic method.* In the *antiseptic method* the same preparations are made for the operation as in the aseptic method, but during the operation sponges impregnated with a chemical germicide are used, and the wound is dressed with gauze containing corrosive sublimate or some other chemical germicide. If the wound is not flushed with a chemical germicide, and is dressed with dry antiseptic gauze, the operation is said to be by the *"dry" antiseptic method.* The antiseptic method is preferred in infected areas. Dry dressings are usually preferable to moist dressings in treating aseptic wounds, because they are more absorbent and do not act as poultices, and dry dressings may be used, even when the wound has been flushed. Some surgeons question the value of antiseptic irrigation in a septic wound, but I believe it removes many bacteria and much poisonous matter and also antidotes toxic material. In suppurating areas it is often best to use moist dressings in the form of antiseptic fomentations. Year by year the aseptic method becomes more popular. Surgeons have learned that the most important factor in asepsis is mechanical cleansing by means of soap and water. The chemical germicide plays a secondary rather than a vital part. By mechanical cleansing great numbers of microorganisms are removed along with dirt, grease, and epithelium. Many bacteria remain, but vast hordes are washed away, and the danger of infection is greatly lessened by thus diminishing the number of bacteria. If a chemical germicide is used without preliminary mechanical cleansing, it is useless, because it cannot destroy bacteria in the epithelium and in masses of oily matter. After mechanical cleansing the germicide is active in destroying the comparatively few bacteria which are naked on the surface. In many regions a strong chemical germicide must not be used (in the abdomen, in the brain, in joints, in the pleural sac, and in the bladder), and in other regions (mucous surfaces and fatty tissue) it is productive of harm rather than good.

Preparation for an Operation.—If the operation is to be performed in a hospital there is, of course, an operating room always ready. If it is to be done in a private house, much careful preparation is desirable. A room in which an operation is to be performed should be well lighted and well ventilated. The northern light is the best. It is advantageous to have an open grate in the room, for then a wood fire can be quickly made to take a chill off the air and ventilation is improved. The morning before the operation the furniture should be removed, the carpet taken up, and the curtains and hangings taken down. If the ceiling and walls are papered, they must be thoroughly brushed. If they are painted, they must be washed with soap and water. Dust is thus removed, and the danger of dust falling into the wound is averted. The floor is scrubbed

with soap and water. The windows should be opened for many hours to thoroughly dry and freshen the room. On the morning of the operation the windows are closed and newspapers are tacked up so as to cover the lower half of each window. Plenty of light is admitted and the curiosity of neighbors across the street cannot be satisfied. The patient's bed is brought into the room and placed in a position where there will be plenty of light for future dressings, and where the surgeon will have access from either side. In order that there may be access from each side the bed must not be in a corner or against the wall. Never use a big broad bed; use a narrow bed. Never have a feather bed, but insist on Treves's advice being followed, and employ a metal bed with a wire netting and hair mattress.

A piece of carpet or rug is spread upon a portion of the floor and the table is set upon it. The table should be so placed that there will be a good light on the field of operation. There are several tables which are very satisfactory. The best for a private house operation is Lilienthal's (Figs. 30 and 31). This table can be folded into a small compass, can be carried in a case with a handle, and is comparatively light and easily transportable. It can be rapidly set up, is firm, and it enables the surgeon to obtain the Trendelenburg position at any moment. A kitchen table does very well. If a kitchen table is used and the abdomen is to be opened a frame should be at hand which, when slipped under the patient, enables the surgeon to obtain the Trendelenburg position. Dr. Joseph Price uses, instead of a table, two trestles and a board like an ironing board. In hospital work I use Boldt's table (Figs. 28 and 29). On the table or board is placed a folded comfortable or several folded blankets and Kelly's pad to catch fluids is laid upon the blankets and is so placed that fluid used in irrigation will flow into it and will be conducted by it to a suitable receptacle.

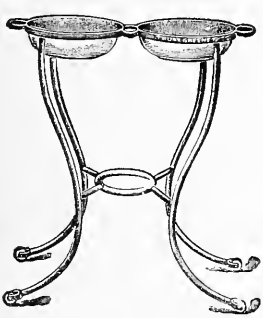


Fig. 24.—Plain double wash-stand.

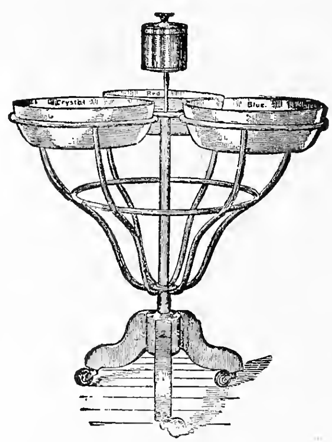


Fig. 25.—Revolving wash-stand.

Around the operating table at proper distances are arranged a table for instruments, a table for dressings, a table for sponges and a basin of bichlorid, and a table for soap and a basin of water. Ordinary wooden tables may be used if they are covered with towels wet in corrosive sublimate solution. In a hospital special tables are used. They are of iron with glass tops. Ordinary basins may be used but enameled or glass basins in stands (Figs.

24 and 25) are the most satisfactory. A couple of buckets should be placed on the floor near at hand. Enameled buckets are the best ones to use. The nurses and assistants should have ready the ether cone, wrapped in a clean towel, sterile sheets, sterile gowns, sterile towels, sterile gauze for sponges and dressings, trays for instruments (Figs. 26 and 27), iodoform gauze, catgut, silk, silkworm-gut, hot normal salt solution, etc., according to the nature of the

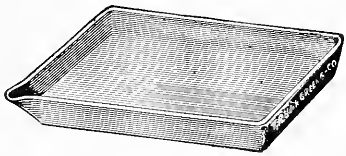


Fig. 26.—Porcelain surgical tray.

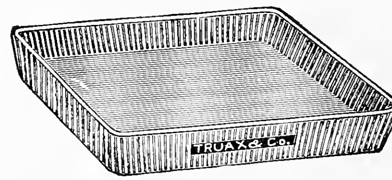


Fig. 27.—Glass surgical tray.

operation. The surgeon should pick out the instruments required. The anesthetizer should lay out a mouth-gag, tongue-forceps, a hypodermatic syringe in working order, ether or chloroform, brandy, tablets of strychnin, and also of atropin.

If the operation is to be performed in a hospital, it is desirable to have the patient admitted two or three days before. He adjusts himself to his

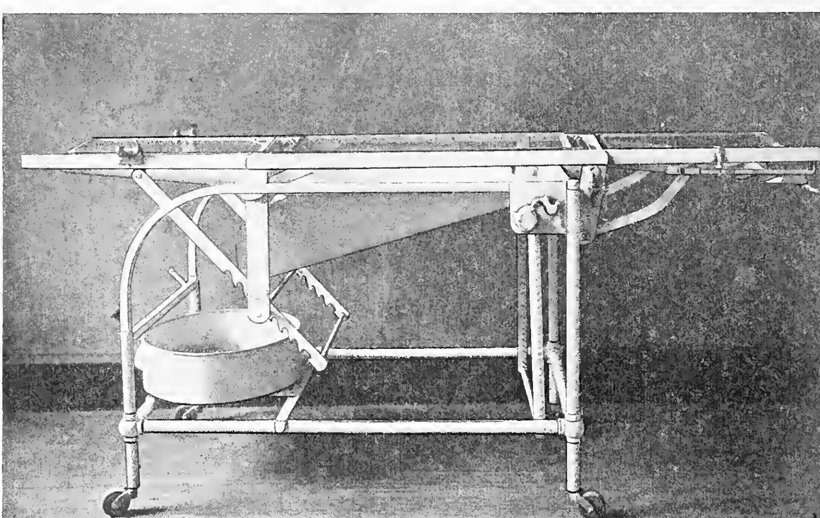


Fig. 28.—Boldt's operating table.

surroundings, becomes accustomed to diminished activity, forms an acquaintance with his nurses and physicians, and, as a rule, becomes less nervous and more calmly confident of the result. The patient is prepared the day before the operation, except in an emergency case.

When the time for the operation arrives, the surgeon and his assistants remove their coats, roll up their sleeves, and, after sterilizing the hands and

forearms, envelop their bodies in aseptic or antiseptic sheets or gowns, to protect the patient and themselves. It is a good plan for the surgeon and his assistants to wear sterile muslin caps. The caps prevent hair, dandruff, and sweat falling into the wound. Mikulicz and some other operators wear over the mouth and nose a respirator or piece of gauze in order to prevent saliva or mucus being projected into the wound while the surgeon talks.

Danger from the Hands.—It is a difficult or impossible matter to absolutely sterilize the hands, but it is fortunate, as Mikulicz and Flügge say, that most of the bacteria of the skin are harmless. The staphylococcus epidermidis albus, however, is constantly present in the epidermis. The hands of some persons are more easily sterilized than those of others. For instance, a hairy, creased hand is more difficult to sterilize than a smooth and almost hair-

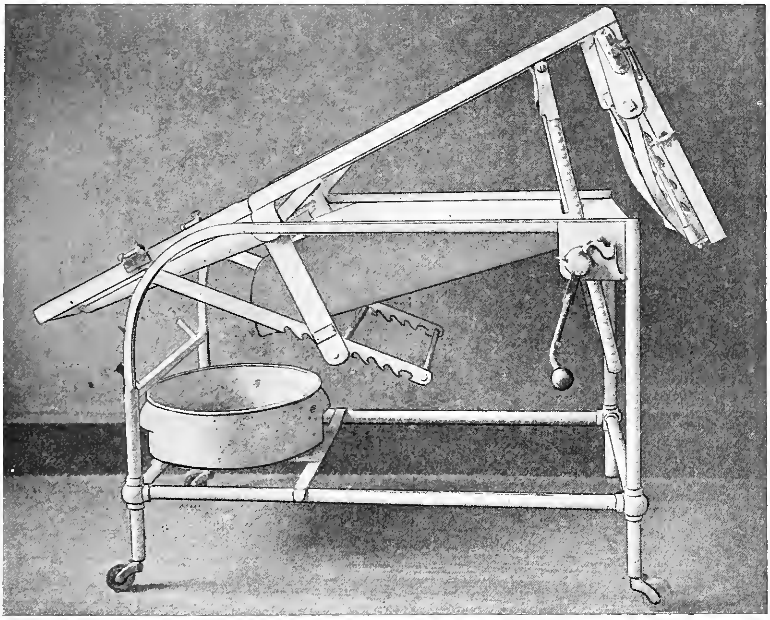


Fig. 29.—Boldt's operating table.

less one; a hand grossly neglected, than one reasonably clean. Germs abound in the epidermis, in the fissures and creases, under and around the nails, on hairs, and in ducts of glands. The surface of the hands may be thoroughly sterile at the beginning of an operation and become infected later, because germs in gland ducts are forced to the surface. Hence, in a prolonged operation, the surgeon should stop from time to time and wash his hands, first in alcohol and then in corrosive sublimate solution (Leonard Freeman).

In view of the difficulty of cleansing the hands, every student must be taught how to do it, and he must become impressed with the fact that the surgical hand is to be regarded as reaching to the elbow. The more hands used in an operation, the greater is the danger of infection of the wound. The surgeon uses retractors and forceps whenever possible, but his fingers

must enter the wound. The fingers of no other person should enter unless absolutely necessary. The basis of all plans of sterilization and the most important part of any plan is mechanical cleansing by scrubbing with soap

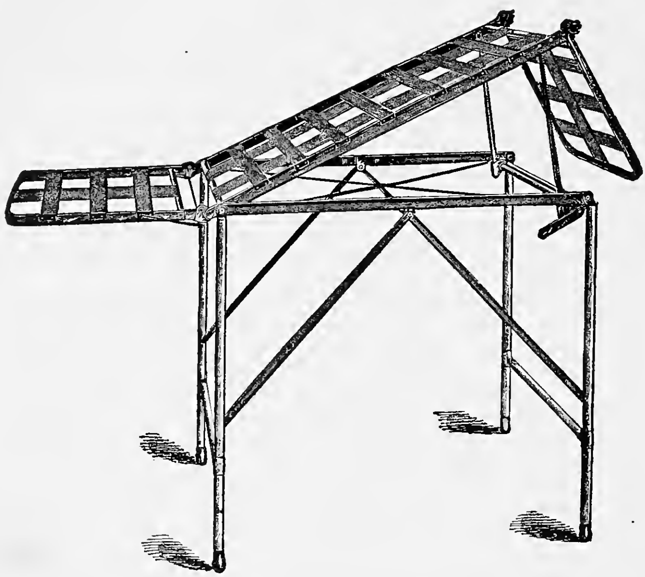


Fig. 30.—Lilienthal's portable operating table.

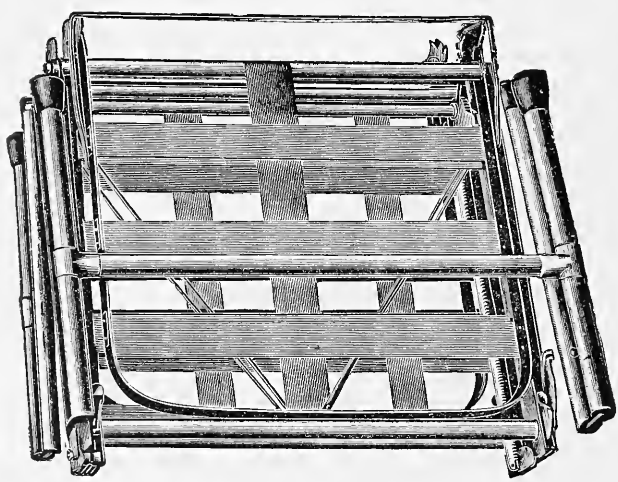


Fig. 31.—Lilienthal's portable operating table, folded.

and water. By this means a quantity of loose epidermis is removed and with it great numbers of bacteria.

Mechanical Cleansing of the Hands and Forearms.—The hands and

forearms may be sterilized in several ways. Any method is preceded by mechanical cleansing, which is carried out as follows: Scrub for five minutes with soap and hot sterile water, giving special attention to the nails and creases in the skin. The water should be as hot as can be borne with comfort as hot water stimulates the sweat glands and the flow of sweat washes out the ducts and during the operation the secretion will be slight. The brush is rubbed in the long axis of the extremity and also transversely. The creases on the back of the hands and fingers will be partially opened by flexing the fingers, and transverse scrubbing will clean the furrows. The furrows on the palmar surface will be opened by extending the fingers, and will be best cleaned by transverse scrubbing (George Ben Johnston). An excellent soap is the ethereal soap of Johnston, which is a solution of castile soap in ether. Green, or castile soap can be used. Many surgeons use synol soap. It is an admirable cleanser but there is no particular advantage in using a soap containing a germicide, as such a soap is practically without germicidal power. The brush employed should be kept in a 1 : 1000 solution of corrosive sublimate or should have been recently sterilized with steam and kept in a sterile glass box (Fig. 32). The nails are cut short, are cleansed with a knife or, better, with an orange-wood stick, which does not scratch them, and the hands are again scrubbed. Very prolonged or very rough scrubbing, especially with harsh agents like marble dust or sand, is actually harmful as it tends to crack the hands and make them rough and it extensively loosens epidermis which may drop into the wound. Epidermis may contain bacteria within it and may infect the wound.

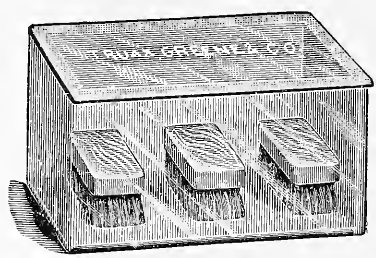


Fig. 32.—Glass brush-box with cover.

Sterilization of the Hands and Forearms.—After mechanical cleansing a germicide is employed to render the parts sterile. Whatever method is adopted it is desirable that it shall not unduly irritate the skin. An occasional operator may use without injury tolerably strong chemicals, but the busy hospital surgeon, who operates perhaps several times or many times a day, cannot use them. Any method which inflames, cracks or roughens the skin makes future sterilization difficult or impossible, hence such a method is undesirable. Four methods are described here:

Fürbringer's Method: After washing off the soap in sterile water the hands are dipped in 95 per cent. alcohol and held there for two or three minutes while the forearms, hands, fingers, and nails are being rubbed with alcohol. Alcohol removes the soap which has entered into follicles and creases, removes desquamated epithelium, enters under and about the nails, and favors the diffusion of the corrosive sublimate under the nails and into the follicles, when the hands are placed later in the mercurial solution. Alcohol also hardens epithelium and keeps it from desquamating into the wound. After using the alcohol the hands are then dipped in a hot solution of corrosive sublimate (1 : 1000), and with the forearms are scrubbed for at least a minute, the nails receiving especial care.

The Welch-Kelly Method: After the hands and forearms have been cleansed mechanically and have been rinsed in sterile water they are immersed for two minutes in a warm solution of permanganate of potassium (a saturated solution in distilled water). This solution causes the cutaneous surface to assume a very dark brown color. The hands and forearms are then immersed in a warm saturated solution of oxalic acid and are held there until decolorized. They are then well washed in sterile water, are next immersed for two minutes in a 1 : 500 solution of corrosive sublimate, and finally are rinsed in sterile water and dried on a sterile towel. The solutions for use in the above method should be contained in jars of the shape of a druggist's percolator so that both the hands and forearms can be immersed at the same time. In this method the permanganate of potash is merely an oxidizer and the oxalic acid is the active germicide. The skin of some persons tolerates the plan very well, others, among whom is the author, find the oxalic acid decidedly irritant when used several times in a day.

The Weir-Stimson Method: This method was suggested by Mr. Rauschenberg, the pharmacist of the New York Hospital, and it was practically applied by Doctors Weir and Stimson. The process is as follows: The hands should be cleansed mechanically as previously directed or, as Weir prefers, by scrubbing with a brush and green soap and in running hot water and cleaning under the nails with a piece of soft wood. Place about a tablespoonful of chlorinated lime in the palm of the hand, place upon the lime a piece of crystalline carbonate of soda (washing soda) one inch square and half an inch thick, add a little water, and rub the creamy mixture over the arms and hands until the rough granules of sodium carbonate are no longer felt. This requires from three to five minutes. At first there is a sensation of heat usually followed by a sensation of coolness. Place the paste under and around the nails by means of a bit of sterile orange-wood. Wash the arms and hands in hot sterile water.* Remove the odor of chlorin by washing the hands and arms in sterile ammonia water of a strength of from ½ per cent. to 1 per cent. (McBurney, Collins, and Oastler, in "International Text-Book of Surgery"). The combination of carbonate of sodium and chlorinated lime is said to set free nascent chlorin, a most efficient germicide. This method has proved extremely efficient in the clinic of the Jefferson Medical College Hospital, although when employed several times a day it may prove decidedly irritant. It is important that crystalline washing-soda be employed. If the bicarbonate is used, nascent chlorin will not be produced, but hydrochloric acid gas will be formed, and the latter gas irritates the skin and is not a satisfactory germicide.

The Sublimate-Alcohol Method: This is the method I personally prefer. It is as follows: Cleanse the hands with soap and water as previously directed. Use 95 per cent. alcohol as in Fürbringer's method (page 57). Dip the hands in 70 per cent. alcohol containing 1 part to 1000 of corrosive sublimate, and rub the hands, forearms, and nails with a piece of sterile gauze wet with this fluid for three minutes. Rinse these parts in the fluid and then rinse in sterile water.

The Use of Gloves.—Some surgeons are so impressed with the impossibility of sterilizing the hands that they wear gloves in operations. Hunter

*Medical Record, April 3, 1897.

Robb is said to have suggested the use of gloves in 1894, but Halsted began to use rubber gloves in 1889. Mikulicz used white cotton gloves. Lockett has proved that cotton and silk are not impervious to micro-organisms, but that rubber is. The thin, seamless rubber gloves which are now made are very satisfactory. They are sterilized by boiling, are then dried, and are wrapped in a sterile towel. In order to insert the hand in them the hand should be dried, the interior of the glove should be dusted with sterile starch or talc powder, and then the nurse should fold forward the wrist part and hold the glove open while the surgeon inserts his fingers into the proper compartments and pushes the hand in. The custom of filling the glove with sterile fluid and then inserting the hand is troublesome and objectionable, because the fingers soon become sodden like those of a washwoman, the sense of touch is impaired, considerable discomfort is occasioned, and the skin is apt to crack open.

Fig. 33.—Showing rubber glove applied.

If, during an operation, a glove becomes infected, a clean one can be substituted for it. Gloves somewhat impair the sense of touch, but a surgeon soon learns to work with them. If they are to be used, the hands should be sterilized just as carefully as when they are not to be used, because, during the operation, the gloves may tear or be punctured by a needle. That it is absolutely necessary to wear gloves in all cases has not been proved. Their use does contribute to success in brain operations, abdominal operations, and joint operations. They are of great value in military surgery for the military surgeons may not have time to prepare his hands and sterile gloves can be always kept ready prepared.

When a surgeon is obliged to place his fingers in an area of virulent infection he may be poisoned. Gloves will save him from this danger. Again, a surgeon should try to avoid bringing his hands unnecessarily in contact with putrid or purulent matter. Though it may not poison him, it grossly infects the surface, renders subsequent cleansing difficult, and endangers

other patients. Gloves will prevent this danger. A surgeon should wear gloves if he is making an examination or performing an operation which is sure to infect the bare hands, and he should wear gloves in an operation if in a previous operation his hands were infected.* A surgeon whose hands are very hairy or sweat much will contribute to the patient's safety by wearing gloves.

Gloves should be worn if the surgeon has a wound or sore upon his hand or chapped hands. When using gloves in a prolonged operation dip the covered hands now and then in corrosive sublimate solution, because the glove may have been punctured or dust may have settled upon it from the air.

Gloves make the hands sweat and if one should be punctured considerable sweat may emerge from the puncture and enter the wound and sweat often contains bacteria. The entry of any considerable amount of sweat is more dangerous to the patient than are well cleaned naked hands, hence gloves may actually favor the infection they are meant to prevent. When they are used the surgeon must take scrupulous care not to puncture them with a needle, clip them with forceps, or tear them with a ligature or suture.

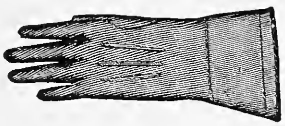


Fig. 34.—Half-long rubber glove.

The closer they fit the less the danger of puncture and one should know accurately what size he requires to fit closely and smoothly without being so tight as to make the fingers numb.

Preparation of Gloves.—Wash with soap and water containing a little ammonia, rinse in sterile water, boil for thirty minutes in a 1 per cent. solution of carbonate of soda. Dry the glove and wrap in a dry sterile towel and keep until it is needed. A pair of gloves should stand about 20 boilings. The surgeon should carry a number of pairs of prepared gloves in his bag, for the use of himself and assistants in private house operations.

Instruments are disinfected by subjecting them to the action of steam in a special sterilizer, or better by boiling them for fifteen minutes in a 1 per cent. solution of carbonate of sodium. They are wrapped into a bundle by means of a towel or piece of gauze and are dropped into the solution. The blades of knives should first be wrapped in cotton to prevent scratching and dulling. After boiling, the instruments should be rinsed in hot sterile water

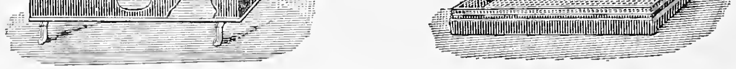


Fig. 35.—*a*, Schimmelbusch's gas-heated apparatus for sterilizing instruments; *b*, wire basket.

* A review of the literature of disinfection of the hands, by Martin B. Tinker and A. B. Craig, will be found in the Phila. Med. Journal, Feb. 15, 1902. See also Edgar R. McGuire, in "The Best Method of Hand Sterilization," in American Medicine, Feb. 28, 1903; Robert T. Morris, on "Rubber Gloves in Surgery," New York Medical Journal, Nov. 22, 1902; and "Sterilization of the Hands," by Charles Leedham-Green, in the Birmingham Med. Review, April 1904.

or in a 5 per cent. solution of carbolic acid and be kept until needed in a pan of sterile water. The carbonate of sodium prevents rusting. In a clinic the boiling is carried out in a Schimmelbusch sterilizer (Fig. 35). In a private house it can be done in a sterilizer such as that shown in Fig. 36, or in a pan, a kettle, or a wash-boiler. A sterilizer with a tray is better than an ordinary pan or kettle, because, when the latter is used, the metal instruments lie in the bottom of the vessel, where the heat is very great, and the temper may be impaired. Boiling unfortunately destroys to some extent the keenness of cutting instruments, the ebullition throwing them about. Hence the knives should be wrapped in cotton to preserve the edges. After sterilization the instruments are placed in trays containing boiled water. After the completion of the operation the instruments should be scrubbed with soap and water, boiled in soda solution, dried, and placed in a closet with glass shelves so they will not gather dust. Instruments can be partially disinfected by keeping them for thirty minutes in a 5 per cent. solution of carbolic acid or better, in a 2 per cent. solution of formalin. Instruments with handles of wood must not be boiled. If such instruments are used, they can be disinfected by the use of carbolic acid or formalin, but they should not be used. Metal instruments, whenever possible, should consist of one smooth piece. Grooves and letters are objectionable, as dirt gathers in such depressions. Ivory handles cannot be boiled.

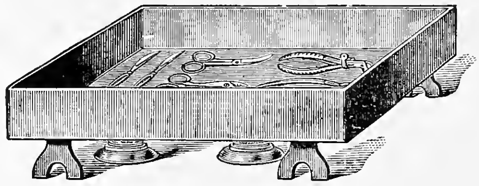


Fig. 36.—Portable sterilizer.

Preparation of the Patient.—Whenever possible give the patient some days' rest in bed before a severe operation. During this preliminary rest study the disease, and study the individual in order to learn his tendencies, peculiarities, etc. The condition of the lungs, the heart, the blood, and the kidneys should be accurately determined. The amount of urine passed in twenty-four hours should be ascertained, and the percentage of urea should be estimated from a sample of the twenty-four hours' urine. The urine is carefully examined for sugar, albumin, casts, acetone, diacetic acid, etc. By the above examinations we may be able to anticipate and provide against certain calamities: We may be led to postpone or abandon an operation, and we will be made able to intelligently select the proper anesthetic. The anesthetizer should during this preliminary period examine the heart and pulse so as to know what these characters are naturally when the patient is free from excitement. Without this preliminary knowledge he cannot accurately appreciate and intelligently interpret some changes induced by the anesthetic. Constipation must be amended by mild laxatives or enemas, and all fermented matter should be removed from the alimentary canal. Constipation increases the danger of wound infection and greatly impairs the comfort of the patient. As previously shown the putrefactive bacteria in the intestinal canal, which are usually harmless and are what Adami calls "potential parasites," may escape. The retention of fermented matter causes catarrhal inflammation and bacteria escape more easily. If they escape they may lead to damage in the wound and even if wound infection from within does not occur, constipation

lessens vital resistance and increases the liability to wound infection from without. Purgatives must not be violent as anything which greatly depresses a person lessens vital resistance and powerful purgatives are powerful depressants. The diet should be bland and nutritious but not bulky. The night before the operation give a saline cathartic, and the morning of the operation employ an enema. Not only do we empty the bowel to lessen the liability to wound infection but we wish the rectum empty at the time of operation for another reason. It is desirable that the rectum be empty, because in shock the absorbing power of the stomach is greatly diminished or is even abolished for the time, and we may wish to utilize the absorbing power of the rectum and give stimulants by enema. When a patient is under the influence of an anesthetic, or when he is profoundly shocked, of course no attempt is made to give stimulants by the mouth. Whenever possible, give a general warm bath the day before the operation. The evening before the operation shave the region if hairy, scrub the entire field of operation, as well as the adjoining regions, with ethereal soap and water; wash with ether or alcohol; scrub with hot corrosive sublimate solution (1 : 1000); apply a layer of moist corrosive sublimate gauze, and place over this dry antiseptic gauze, a rubber dam, and a bandage. Many surgeons apply a poultice of green soap for many hours before applying a chemical germicide, in order to separate masses of epithelium and with them many germs. This method is particularly useful in cleansing the scalp. On removing the dressings to perform the operation, scrub the part with soap and water, wash it with sterile water and then with alcohol, surround the field of operation with dry sterile sheets and towels and scrub the exposed area with a hot solution of corrosive sublimate (1:1000). Murphy prevents infection from the cutaneous surface by spreading a specially prepared rubber solution over the sterilized operation area. The solution is sterile and sticks to the skin and is applied after the skin has been washed first with ether and then with alcohol. The rubber is dissolved in acetone and is painted on the skin. The incisions are made through the artificial skin of rubber and the rubber is removed when the surgeon is ready to introduce the sutures. Thus infection of the wound with contaminated secretion of the skin glands is prevented, for, as Murphy says, this elastic covering is "in reality a non-secreting, sterile, artificial derma, for the period of operation" ("General Surgery," edited by John B. Murphy, vol. ii, 1905). The patient must be carefully protected from cold by wrapping him in blankets and often by having him wear specially prepared drawers with feet. After the completion of an operation and the application of the dressings the patient is returned to his room or the ward, care being taken to protect him from cold or draughts. In emergency cases disinfection can only be practiced just previous to the operation. Disinfection in such cases can be thoroughly effected by shaving, scrubbing with soap and water, washing with alcohol, and then using chlorinated lime and washing soda.

Disinfection of Mucous Membranes.—It is impossible to thoroughly disinfect mucous membranes. We must not scrub forcibly, and we must not use powerful antiseptics because they are irritant and also because they may be absorbed. The best that can be done in the vagina is to rub lightly, when possible, with a bit of moist absorbent cotton and irrigate with a solution of boric acid or with normal salt solution. Another method is to sponge the

vagina with creolin and Johnston's ethereal soap (1 and 16) and irrigate with hot saline fluid or boric acid.

The *rectum* is prepared by washing out all retained feces by the use of copious high injections and by irrigating with salt solution or boric acid.

The *mouth* is prepared by having snags of teeth and tartar removed and decayed teeth removed or plugged. For several days before the operation scrub the teeth twice a day with a soft brush and castile soap; and every three hours, when the patient is awake, rinse the mouth with peroxid of hydrogen and spray the nares and nasopharynx with boric acid solution.

The *urethra* is prepared by the administration for several days of salol or urotropin and by frequent irrigation of the urethra and bladder with boric acid solution or normal salt solution or a solution of permanganate of potash (1 : 6000).

Preparation of a Patient for an Operation upon the Stomach (see page 918).

Irrigation is often practiced in septic wounds, but is not required in aseptic wounds. In a septic wound gentle irrigation with a germicide is advisable. It removes bacteria and toxins and antidotes retained toxins. Irrigation must never be forcible for fear it may disseminate infection. Among irrigating fluids we may mention corrosive sublimate, carbolic acid, peroxid of hydrogen, boric acid solution, and normal salt solution. Hot normal salt solution is the best agent with which to irrigate the peritoneal cavity, the pleural sac, the interior of joints, and the surface of the brain. This solution contains 0.7 per cent. of sodium chlorid.

Many surgeons employ Landerer's dry method in operating aseptically. No fluid is applied to the wound. As the wound is enlarged gauze sponges are packed in to arrest hemorrhage. On the completion of the operation the sponges are removed, bleeding points are ligated, and the wound is often closed without drainage.

Ligatures and Sutures.—In using sutures always remember that they must be tied firmly, but never tightly. A tight suture will cut when the wound swells and will thus fail of its purpose; further, it produces an area of tissue necrosis, which is a point of least resistance in and about which infection is prone to occur.

Catgut.—The favorite ligature material is catgut. Catgut undergoes absorption in the tissues. Years ago attempts were made by Scarpa, Crampton, and Physick to use absorbable ligatures. Sir Astley Cooper tried catgut. These attempts failed because the material employed was septic, suppuration ensued, the wound gaped, and the ligature was cast off prematurely. Surgeons remained content with non-absorbable ligatures of silk or linen. These ligatures were not cut short, but a long end was left to each one, and the ends were allowed to hang out of the wound. The ligatures were lightly pulled upon from time to time, and when they loosened or cut through were removed. Catgut is the submucous coat of the intestine of the sheep, and is the material from which violin strings are made. It was reintroduced into surgery by Lister. It is obtained in the following manner: The small intestine, after separation from the mesentery, is washed in water, laid upon a board, and scraped with a metal instrument. Thus the mucous coat and the muscular coat are scraped away, and the submucous coat only remains. The submucous coat is cut into strips, and each strip is twisted into a coil. Raw cat-

gut is an infected material. It is difficult to sterilize, because in the twisting many organisms get into the interior of the strand, where it is impossible for antiseptics to reach them. Raw catgut obtained from animals dead of splenic fever contains spores of anthrax. If not thoroughly disinfected, catgut is dangerous, and some surgeons consider its cleanliness always a matter of grave question and will not use it. Surgeon's catgut can be bought from the dealer in skeins containing 30 yards. It should be rough and yellow. The smooth white variety should not be gotten. It has been rubbed smooth with a piece of glass and bleached with a chemical, and in consequence is weak and unreliable. The smallest size is known as double zero, then come single zero, No. 1, No. 2, No. 3, and No. 4. The usual ligature size is No. 2. Nos. 3 and 4 are only used for tying thick pedicles. Nos. 1 and 2 are used for suturing the dura and peritoneum, and No. 1 for tying small vessels in the brain. McBurney and Collins state that when catgut is used to tie delicate tissue (omental masses, intestinal surfaces, etc.), it must first be softened by immersing for half a minute in normal salt solution. If this precaution is neglected and wiry catgut is used, the ligature or suture will cut and hemorrhage will occur.* The greater the diameter of the gut the more uncertain is the sterilization. Nos. 3 and 4 are of doubtful cleanliness, no matter what method of sterilization is employed, and a strand though clean upon the surface may be infected in its interior. When a strand which is infected within is used by the surgeon the tissues are not infected promptly but after some days when the catgut has been partially absorbed and the spores or bacteria within the strand have been set free. Many late infections are due to catgut infected in the interior of the strand. The smaller sizes I believe can usually be satisfactorily sterilized.

If catgut is thoroughly freed from bacteria, and the wound in which it is used is aseptic, it is a most satisfactory ligature material, is absorbed in the wound after being cut off short, and produces no trouble although it does increase slightly wound secretion. The smaller sizes are absorbed in four or five days, No. 2 lasts from nine to ten days, Nos. 3 and 4 from ten days to three weeks.

One of the following methods of preparation may be used:

Boiling in Alcohol.—The catgut is soaked in ether for twenty-four hours to remove fat. It is then wound on glass spools, transferred to alcohol, and boiled under pressure. The boiling is conducted in a heavy metal jar with a well-fitting screw-top. The jar is half filled with alcohol. The spools of catgut are placed in the jar, the lid of the jar is screwed down, and the apparatus is immersed in boiling water for half an hour. The gut is kept in this jar until needed. Fowler's catgut is prepared by boiling in alcohol. It is placed in hermetically sealed U-shaped glass tubes. Each tube contains alcohol and 12 ligatures. The alcohol is boiled *by immersing the tube in* boiling water.

The Cumol Method.—The cumol method is employed by Kelly in the Johns Hopkins Hospital, and is known as Krönig's method. Cumol is a fluid hydrocarbon which boils at 179° C. Catgut is wound upon spools of glass, and these are placed in a beaker glass, the bottom of which is covered with cotton. A bit of cardboard is placed on top of the beaker, and through

* "International Text-Book of Surgery."

a small perforation in the cardboard a thermometer is introduced. The beaker is placed in a sand-bath and the bath is heated by means of a Bunsen burner. The temperature is gradually raised to 80° C., and is kept at this point for one hour, in order entirely to remove moisture from the gut. Cumol, at a temperature of 100° C., is poured into the glass, and the heat is increased until the temperature of the cumol is a few degrees below its boiling-point (165° C.). For one hour this temperature is maintained. Then the cumol is poured off and the catgut is allowed to remain for a time in the sand-bath at a temperature of 100° C., in order to dry. It is transferred for keeping into sterile glass jars or test-tubes.*

The Claudius Method.—The iodin catgut is prepared by the Claudius method. Mr. Moynihan, of Leeds, makes Claudius catgut as follows: In 10 ounces of sterile water dissolve 1 ounce of crystals of iodid of potassium. When all the crystals are dissolved add 10 ounces of sterile water and then add 1 ounce of iodin in crystalline form. Dilute the mixture with 4 pints of sterile water. The result is a 1 per cent. solution of iodin and potassium iodid. After the usual preliminary preparation, place the gut in the mixture and keep it in it for at least eight days before using. It can be kept in it without harm for a number of months.

The Formalin Method.—The formalin method is advocated by the elder Senn. The catgut is wound on glass test-tubes, and is immersed in an aqueous solution of formalin (2-4 per cent.) for twenty-four to forty-eight hours. It is placed in running water for twelve hours to get rid of the formalin. It is boiled in water for fifteen minutes, is cut in pieces and tied in bundles, is placed in a glass-stoppered jar, and is kept ready for use in the following mixture: 950 parts of absolute alcohol, 50 parts of glycerin, and 100 parts of pulverized iodoform. Every few days the mixture should be shaken.

Senn's process is a modification of Hoffmeister's. Even sterile catgut contains a toxic substance which increases wound secretion, has a poisonous effect on body-cells, and favors to some extent limited suppuration. Senn maintains that to counteract this influence gut should not only be sterile, but should be antiseptic, to inhibit the growth of pyogenic organisms which reach the wound from without during operation or subsequently by the blood.

Dry Heat Method.—Boeckman wraps catgut in paraffin paper, seals it in a paper envelope, puts it in the sterilizer, and subjects it to dry heat. For three hours it is heated to a temperature of 284° F., and for four hours to a temperature of 290° F. The envelope can be carried in the pocket or the instrument bag. When the gut is wanted the end of the envelope is torn off, an assistant with sterilized hands unwraps the paraffin paper, and the gut is dipped for a moment in sterile water to make it pliable.†

Corrosive Sublimate Method.—A method which has been largely used is to take raw catgut, keep it in ether for twenty-four hours, soak it for twenty-four hours in an alcoholic solution of corrosive sublimate (1 : 500), wind it on sterilized glass rods, and place it for keeping in ether or in alcohol.

Johnston's quick method of preparing catgut is as follows: Place it for twenty-four hours in ether; at the end of this period place it in a solution

*See McBurney and Collins, in "International Text-Book of Surgery," and Clark, in "Johns Hopkins Hospital Bulletin," March, 1896.

†James E. Moore, in "Phila. Med. Journal," June 22, 1898.

containing 20 grains of corrosive sublimate, 100 grains of tartaric acid, and 6 ounces of alcohol. The small gut is kept in this for ten or fifteeen minutes, the larger gut from twenty to thirty minutes, but never longer. It is placed for keeping in a mixture containing 1 drop of chlorid of palladium to 8 ounces of alcohol. This gut is strong and reliable. At the time of operation the gut is placed in a solution one-third of which is 5 per cent. carbolic acid solution and two-thirds of which is alcohol.

Preparation of Chromicized Catgut.—Chromicized catgut is absorbed less rapidly by the tissues than ordinary catgut. It is used to tie thick pedicles and large arteries, to suture nerves and tendons, and as a suture material in the radical cure of hernia. Chromicized gut, No. 3 and No 4, will remain unabsorbed in the tissues from four to six weeks. The gut should be soaked in ether for twenty-four hours, and be immersed for twenty-four hours in a 4 per cent. solution of chromic acid in water. The gut is then dried in a hot-air sterilizer and is disinfected by one of the several methods. The cumol method is satisfactory.

How to Tie Catgut.—Catgut is tied in a reef knot (square knot) and distinct ends are left on cutting. The second knot, if pulled too tightly, may break the ligature. Moist catgut is slippery and is hard to tie. If a large vessel is tied by catgut, a third knot should be used and the ends cut close to the knot. Really strong catgut can be tied in a surgeon's knot.

Kangaroo-tendon and Its Preparation.—This material is obtained from the tail of the great kangaroo. It is especially useful for buried sutures in hernia operations; it will be absorbed in the tissues, but only after a long time (sixty to seventy days). Kangaroo-tendon is not grossly infected as is catgut. The material is obtained from a recently killed animal and is promptly dried in the sun. This suture material was introduced by Dr. Henry O. Marcy. It can be prepared in the same manner as the chromicized catgut, and it ought always to be chromicized. Marcy's plan of preparation is as follows: Soak the dried tendon in a solution of corrosive sublimate (1 : 1000) and separate the individual strands. The individual strands will be of equal diameter and from 10 to 20 inches in length. The diameter depends on the size of the animal. Dry each strand in an antiseptic towel. Chromicize the tendons and keep them until needed in boiled linseed oil containing 5 per cent. of carbolic acid. Before using the strands take them out of the oil, wipe off the oil with a sterile towel, and immerse the tendon for half an hour in a 1 : 1000 solution of bichlorid of mercury. This immersion does not make them swell and soften and does not weaken them as it would catgut.

The following method of preparation is recommended by Charles Truax ("Mechanics of Surgery"): Soak the dried tendon until it becomes supple, in a 1 : 1000 solution of corrosive sublimate. Separate the material into individual tendons, place them lengthwise between two towels; dry them; make them aseptic by soaking in a solution of formalin, as we would do with catgut (see above). After washing out the formalin chromicize the tendon by placing it in a fresh 5 per cent. solution of carbolic acid containing 1:4000 parts of chromic acid. When the tendons become "dark golden brown" in color, they are removed from the chromic acid solution, dried between sterile towels, and placed for keeping in 10 per cent. carbolized oil. When wanted, they are removed from the oil, and wiped with a sterile towel saturated with bichlorid solution (1 : 1000). Kangaroo-tendon is tied in a reef knot.

Silk.—This material can be used for both ligatures and sutures; many sizes should be kept on hand. Silk is very strong, soft, extremely supple, and does not swell or irritate the tissue. It can be tied into very firm knots. Ordinary surgical silk is a form of twisted silk—that is, several or many strands are twisted into one. Cable twist or Tait's silk is very strong and is used for tying large pedicles. Braided silk is extremely strong and is made by plaiting together several strands of twisted silk. Floss silk is "a straight fiber slightly twisted" (Truax). Silk is usually tied in a reef knot, but occasionally in a surgeon's knot. White silk may be used, or black silk, which is more easily visible. Silk becomes encapsuled in the tissues. It is not absorbed at all or only after a very long time. It is not a good material for buried sutures, as in the long run it may form a sinus.

Preparation of Silk.—Sutures of silk should be boiled for half an hour before using in a 1 per cent. solution of carbonate of sodium. Some surgeons keep the silk after boiling in sublimated alcohol (1 : 1000) or carbolic solution (5 per cent.), but it is better to prepare it just before using. A convenient method of preparation is to wind the silk on a glass spool, place the spool in a large test-tube, close the mouth of the tube with jewelers' cotton, introduce the tube into a steam sterilizer, and subject it to a pressure of 10 pounds for twenty minutes, repeating the process the next day. These tubes are carried in wooden boxes sealed with rubber corks.

Horsehair and Its Preparation.—This is used for effecting very neat approximation where only light sutures are required; for instance, in wounds of the face. Its chief use is for capillary drainage. It is prepared by washing and then boiling for fifteen minutes in a 4 per cent. solution of carbonate of sodium. It is kept until needed in sublimated alcohol (1 : 1000).

Silkworm-gut and Its Preparation.—This material contains fewer bacteria than catgut and does not swell when introduced into a wound. It is strong, solid, smooth, non-irritating, can be drawn through the tissues with slight force, and does not tend to cut the tissue as does a metallic suture. The designation silkworm-gut is a misnomer; the material is not gut at all but is obtained from the silk-producing glands. Italy supplies most of the gut used by fishermen but the gut used by the surgeon comes chiefly from Murcia in Spain. When the silkworms are just ready to spin they are placed in vinegar and water for a number of hours and are thus killed. Each worm is opened and the silk-producing glands are clearly exposed and each gland is drawn by its ends into a single thread. The threads are dried in the air and assume a reddish color (M. J. Triollet, in "Bulletin des Sciences Pharmacologiques," 1905, No. 5. Quoted in "Lancet," Feb. 3, 1906). "This crude silkworm-gut is sold to the manufacturer and further treated. It is first boiled in alkaline water to remove fat and blood and is then dried in the sun, being protected from dust. It is next polished by means of slightly oiled pumice stone. The gut is then bleached with sulphurous acid and rubbed vigorously with chamois leather to remove dust and sulphur" ("Lancet," Feb. 3, 1906). It is a very valuable material but is not used for ligatures as it cannot be tied as firmly as catgut and because when left buried in the tissue the sharp ends may sitck and irritate and a point of least resistance may be created. Silkworm-gut is prepared by placing it in ether for forty-eight hours and in a solution of corrosive sublimate (1 : 1000) for one hour,

or it can be boiled in plain water for half an hour. It is carried in a long tube filled with alcohol. A few minutes before using the gut is placed in carbolic acid and alcohol (one-third of the solution is a 5 per cent. solution of acid, two-thirds of it is alcohol). Silkworm-gut is tied by the surgeon's knot.

Celluloid Thread and Its Preparation.—This material is warmly advocated by Pagenstecher. He calls it celluloid yarn, and prepares it from English gray linen thread. I have used it with much satisfaction. It is strong, smooth, flexible, and the knot holds firmly; it can be sterilized by any method used for raw silk, and sterilization by dry heat actually increases its strength. Its one disadvantage is that it absorbs about 40 per cent. of fluid, but does not soften. The celluloid is added after the thread has been boiled in a 1 per cent. solution of carbonate of soda wiped or wrapped in a sterile towel and dried in hot air or steam. It is then dipped in a solution of celluloid heated in a hot-air sterilizer, and packed in sterile boxes (Schlutius, in "Pacific Med. Journal," Jan., 1900; Keen and Rosenberger, in "Phila. Med. Journal," May 10, 1900). Celluloid thread can be used for sutures or ligatures.

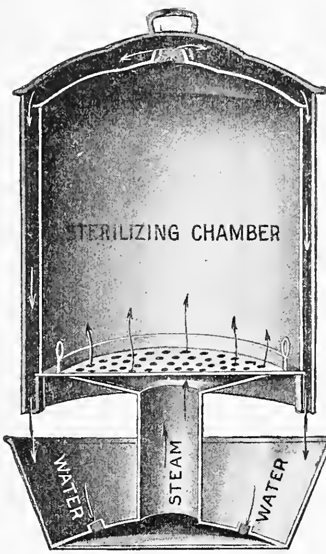


Fig. 37.—Arnold steam sterilizer (Fowler).

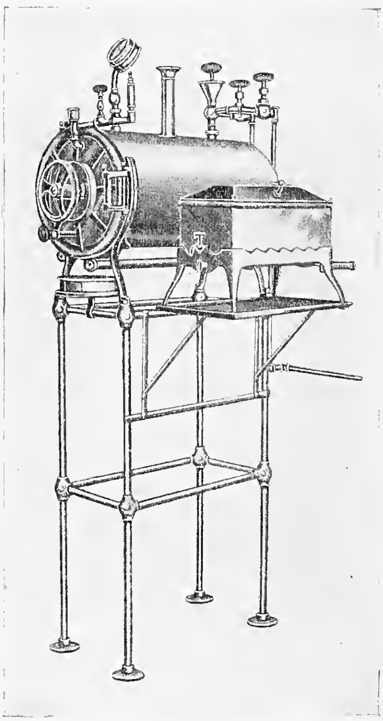


Fig. 38.—Small steam-pressure sterilizer and instrument boiler (Fowler).

Silver wire is prepared by boiling. It is a very useful suture material, as it can be thoroughly sterilized and has an inhibitory effect on the growth of bacteria. Some surgeons use it for buried sutures, but many are opposed to using it thus on the ground that it is apt to lead to sinus-formation.

Most wounds are closed by interrupted sutures of silkworm-gut, but silk, catgut, chromic catgut, or silver wire can be used. The old continuous suture (glovers' stitch) is rarely used except as a buried suture. An admir-

able closure can be effected by Halsted's subcuticular stitch, and scarcely any scar results (page 51). Marcy's buried tendon sutures are very valuable, especially in hernia operations and in various operations upon the abdomen.

Dressings are made of cheese-cloth. In order to make *antiseptic gauze* the cheese-cloth is boiled in a solution of carbonate of sodium, rinsed out, and dried; it is then soaked for twenty-four hours in a solution containing 1 part of corrosive sublimate, 2 parts of table salt, and 500 parts of water. It is placed in clean jars with glass lids, and it may be kept moist or dry.

Sterilized or aseptic gauze is prepared by boiling in carbonate of sodium solution, etc., as described under Antiseptic Gauze. The gauze is then wrapped in a towel and is placed in a steam sterilizer (Figs. 37, 38, and 39) for an hour. It is kept until wanted in sterile glass jars with glass lids. The pads for sponging are made by rolling up portions of sterile gauze. *Ashton's abdominal pads* are made by taking several layers of sterile gauze, each piece

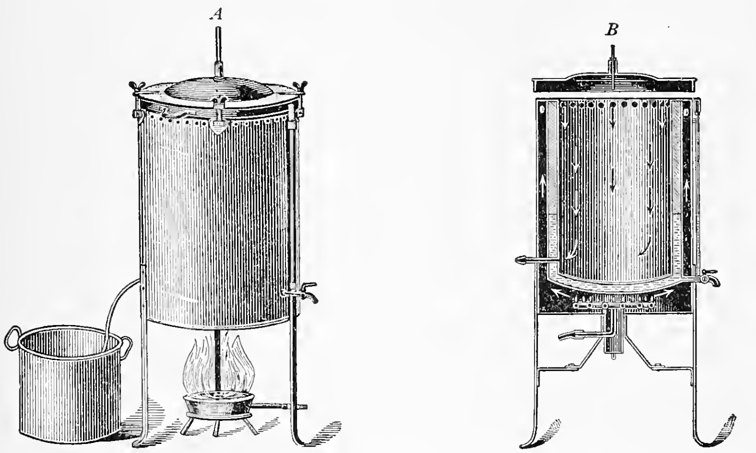


Fig. 39.—Lautenschläger's steam sterilizer for dressings: *A*, Exterior view; *B*, cross-section.

about six inches long and four inches wide, running a stitch around the margin, and sewing a piece of tape into one corner.

Sterile absorbent cotton is prepared in the same manner as gauze. Cotton is useful as a dressing to supplement gauze, being placed on the outside of the gauze. It absorbs quantities of serum, but will take up very little pus.

Iodoform gauze is very useful for packing in the brain and abdomen, for packing abscesses and tuberculous areas, and for dressing foul wounds. It is prepared as follows: Make an emulsion composed of equal parts by weight of iodoform, glycerin, and alcohol, and add corrosive sublimate in the proportion of 1 part to 1000 of the mixture. This mixture stands for three days. Take moist bichlorid gauze, saturate it with the emulsion, let it drip for a time, and keep it in sterilized and covered glass jars (Johnston).

Lister's *cyanid gauze* (double cyanid of zinc and mercury) is not certainly antiseptic, and must be dipped into a corrosive sublimate solution (1 : 2000) before using. All forms of gauze can be bought ready prepared from reliable firms.

Some surgeons place *silver foil* upon a wound before applying the gauze (Halsted, page 31). Small wounds in which drainage is not employed may often be dressed by laying a film of aseptic absorbent cotton over the wound and applying, by means of a clean camel's-hair brush, *iodoform collodion* (grs. xlviij of iodoform to ℥j of collodion). Among other materials sometimes used for dressing wounds the following should be mentioned: Wood wool, absorbent wool, moose pappe, oakum, jute, peat, and sawdust.

Protectives.—A protective is a material placed directly upon wounds to shield them from irritation and infection and outside of dressings to diffuse and prevent the escape of discharge. The commonly used protectives are Lister's oil silk protective, gutta-percha tissue, rubber dam, waxed paper, paraffin paper, mackintosh, and silver foil. Undoubtedly, many antiseptic agents destroy young cells and in this way hinder repair. The same is true of certain rough dressings.

R. T. Morris showed us that gauze and particularly cotton are injurious to a healing wound. A non-irritant protective laid directly upon a wound may be useful by saving new cells from injury by an irritant germicide and from being pulled away at each change of dressings.

Among the best protectives in common use are Lister's protective, gutta-percha tissue, and silver foil. Morris condemns gutta-percha tissue as irritant. He uses thin gold-beaters' skin made from the peritoneum of the ox, which material he calls Cargile membrane, after an Arkansas physician who introduced it into practice. The advantage of this material is that moisture cannot penetrate and new cells do not adhere. I have used it with satisfaction in some cases but in wounds and ulcers prefer silver foil (see "An Experimental and Histological Study of Cargile Membrane," by A. B. Craig and A. G. Ellis, "Annals of Surg.," June, 1905).

Silver foil, Lister's protective, or gutta-percha tissue is laid directly upon a wound, the dressing being placed above it. Silver foil comes in books and is sterilized by dry heat. Gutta-percha tissue it sterilized by washing with soap and water, rinsing in sterile water, and soaking in a solution of corrosive sublimate. Lister's protective is employed to save the wound from the irritation of carbolized dressings. In the United States, if it is desired to place an impermeable material *over* a dressing, a rubber dam is usually employed. A rubber dam before being used should be washed with soap and water and soaked in a solution of corrosive sublimate.

The use of an impermeable material on the outside of the gauze dressing is not nearly so common as formerly. In an aseptic wound dry dressing uncovered by rubber is the most useful. When a dressing is covered by an impermeable material it becomes wet, acts as a poultice, and the discharges on the dressings may undergo decomposition.

Drainage.—Drainage is used in all infected wounds, in most very large wounds, in wounds to which irritant antiseptics have been applied, in cases in which large abnormal cavities exist, in very fat people, and in individuals with such thin skin that we dare not apply firm pressure (see page 52). Drainage is obtained, when needed, by rubber or glass tubes, by strands of horsehair, silkworm-gut or catgut, by pieces of gauze, and occasionally in the abdomen by Mikulicz's bag or tampon by which we obtain pressure to arrest hemorrhage and also secure drainage (Fig. 43). Rubber drainage

tubes (Fig. 40, *B*) are rendered sterile by boiling in plain water. They are kept until wanted in a mercurial solution. This solution should be changed every few days, because the mercury is apt to be precipitated as sulphid. Glass tubes are sterilized by boiling. A bit of rubber tissue is sometimes used for drainage. Gauze, catgut, etc., are known as capillary drains. When moist they drain serum excellently, but pus very badly or not at all. Pus requires tubular drainage. Drainage-tubes or strands are brought out at a portion of the wound which will be dependent when the patient is recumbent.

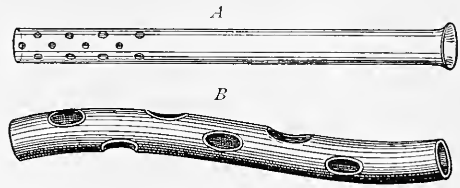


Fig. 40.—Drainage-tubes; *A*, Glass; *B*, Rubber.

Change of Dressing.—When a change of dressings is determined upon the surgeon should carefully sterilize his hands and forearms and should have at hand a warm solution of corrosive sublimate, common salt solution, an irrigator, iodoform, iodoform gauze, scissors, forceps, basins (Figs. 41 and 42), etc. Dressings should be moistened before removal with salt solution or corrosive sublimate solution. If they stick to the part a spray of hydrogen dioxid projected from an atomizer between the skin and dressings will soon loosen them. Dressings must be changed as soon as soaking with blood or wound-fluid is apparent. If the wound becomes uneasy and painful or if constitutional symptoms of wound infection arise the dressings must be removed to permit of inspection of the wound. A change of dressings must be effected with all of the aseptic care employed in a surgical operation. Dressings are not dispensed with until the wound is soundly healed.

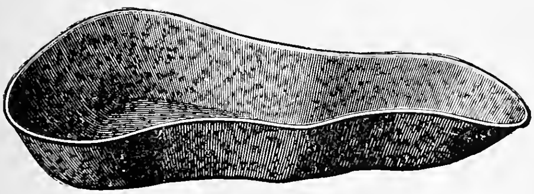


Fig. 41.—Smith's dressing basin.

Removal of Stitches.—Buried stitches of animal material are not removed by the surgeon but are gradually absorbed in the tissues. Buried stitches of silk or silver wire, which are used by some surgeons, although they are not absorbed in the tissues, may never require removal but in some cases cause sinuses to form and a sinus from a suture or ligature will not heal until the suture or ligature is removed.

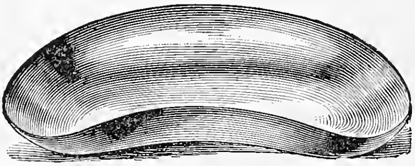


Fig. 42.—Plain dressing basin.

If a catgut stitch is passed through the skin and tied externally the loop in the tissue is absorbed but the knot and remainder of the loop is on the surface and is not absorbed but remains adherent to the wound and the surgeon need only lift it off with forceps. Catgut is used as a material for cuta-

neous suturing in the operation of circumcision. When a skin wound is closed by unabsorbable sutures, as it usually is, the surgeon at the proper time takes forceps and scissors and removes the stitches. Stitches may usually come out from the sixth to the eighth day, although if there is much tension on the edges of the wound they are allowed to remain several days longer. In large wounds, half of the stitches are taken out at one time, the remainder being allowed to remain for a couple of days longer. When a stitch begins to cut, it is doing no good, and it should be removed, no matter how short a time it has been in place. If it is allowed to remain, it will cut into the wound, make a stitch-abscess, and cause an irregular suture-line. In order to remove a stitch pick up an end distal from the knot with forceps, lift it lightly, cut one side of the suture close to the skin by scissors, and remove it by pulling in the direction of the side on which the suture was cut (Fig. 44).

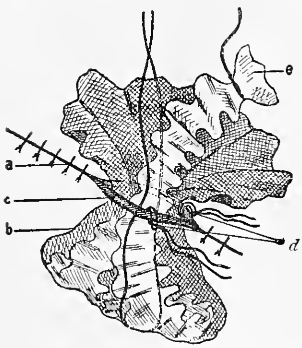


Fig. 43.—Mikulicz's bag; *a*, Abdominal sutures; *b*, gauze bag; *c*, abdominal wound; *d*, loops in the abdominal wall; *e*, gauze strip.

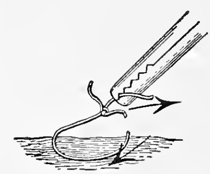


Fig. 44.—Method of extraction of a suture (Esmarch and Kowalzig).

Artificial Sponges.—Bits of gauze should be used, each piece being thrown away as soon as it is soaked with blood or tissue fluid. Gauze pads can be used, soaking them in an antiseptic solution and squeezing them out from time to time during an operation.

Preparation of Marine Sponges.—Marine sponges are seldom used. Gauze pads are preferred. Marine sponges absorb admirably, but they are hard to clean when new and cannot be certainly sterilized in their interiors after becoming infected. They may be prepared as follows: Beat out the dust; place them for forty-eight hours in a solution of hydrochloric acid (15 per cent.); wash them with water; place them for one hour in a solution of permanganate of potassium (ʒiij to 5 pints of water); soak for four hours in a solution containing 10 ounces of hyposulphite of sodium, 5 ounces of hydrochloric acid, and 3 pints of water; wash with running water for six hours. Keep the sponges in a jar containing corrosive sublimate solution (1 : 1000). After using, wash in hot water, soak for half an hour in a solution of sodium carbonate (1 : 32), wash again in hot water, and replace in corrosive sublimate.

Senn's Decalcified Bone-chips.—Take the shaft of the tibia or femur of a recently killed ox, saw it into portions two inches in length, remove the marrow and periosteum, and place the fragments of bone in a 15 per cent. solution of hydrochloric acid. Change the solution every twenty-four hours. In from two to four weeks the bone will be decalcified. Wash in distilled water, place the pieces of decalcified bone for a few minutes in a dilute solution of potash to neutralize the acid, and then immerse for twenty-four hours in distilled water. The portions of bone are cut into strips in the direction of the long axis of the segments. Each strip is three-quarters of an inch wide

and should be sliced into bits one millimeter thick. These chips are kept in an alcoholic solution of corrosive sublimate (1 : 500).

Bandages.—For retaining dressings upon wounds the unbleached muslin bandage may be used, but in most cases the gauze bandage is employed. The gauze bandage soaked in corrosive sublimate solution is antiseptic; it does not partly seal the dressing and act like protective; it can be applied firmly, evenly, and rapidly, and is very comfortable.

III. INFLAMMATION.

Definition.—When the tissues are injured they react or respond, and this reaction or response is known as inflammation. The process of inflammation was defined by the late Sir John Burdon-Sanderson as "the succession of changes which occur in a living tissue when it is injured, provided that the injury is not of such a degree as at once to destroy its structure and vitality." Professor Adami, in his article upon inflammation in Allbutt's "System of Medicine," points out that this definition really includes too much. He alludes to the hemorrhage which occurs in the liver after a traumatism, and the subsequent changes in the extravasted corpuscles, and points out that these changes are not inflammatory phenomena. This definition, however, includes all inflammatory conditions, is largely employed, is very useful, indicates the cause, and, as Burdon-Sanderson says, makes clear that inflammation is a process and not a state (Adami). Adami's definition is as follows: "The series of changes constituting the local manifestation of the attempt at repair of actual or referred injury to a part, or, briefly, the local attempt at repair of actual or referred injury." The changes alluded to in Burdon-Sanderson's definition comprise (1) changes in the vessels and the circulation, (2) departure of fluids and solids from the vessels, and (3) changes in the perivascular tissues.

Vascular and circulatory changes were formerly thought to be absolutely essential to inflammation in both vascular and non-vascular tissues. In the former they occur in the inflamed tissues; in the latter (cornea and cartilage) they are manifest in neighboring tissues from which the non-vascular area derives its nutritive material. As a matter of fact, in inflammation, vascular changes are almost always present; but in a rather trivial corneal inflammation the episcleral vessels may not dilate, and the only white corpuscles which gather in the damaged area are those which come from the lymph-spaces of the cornea. Inflammation in any tissue will not be accompanied by vascular dilatation unless the process reaches a certain stage of severity.

Active Hyperemia.—When an irritant is applied to tissue there may be a momentary arterial contraction due to irritation of the nerves, but this contraction is transitory, and is not an inflammatory phenomenon. The first vascular phenomenon is dilatation of all the vessels,—capillaries, venules, and arterioles,—appearing first and being most pronounced in the small arteries. As a result of the dilatation there are increased rapidity of circulation and increased determination of blood to the part, and the area of hyperemia becomes warmer than is normal. This condition of increased circulatory activity is known as "active hyperemia" (Fig. 46).

Active hyperemia is an increase in the amount of moving blood in a part. Passive hyperemia is an increase in the amount of blood in a part, but not of moving blood, as passive hyperemia or congestion is due to venous obstruction, and the blood is stagnated. Diminution in the amount of blood in a part is ischemia. Local anemia is the complete cutting-off of the blood-supply of a part.

In active hyperemia more blood goes to the part and more blood passes through it, an increased amount of venous blood comes from the hyperemic area, the venous tension is increased, and the veins may even pulsate. The capillaries, which under ordinary circumstances contain but few blood-cells (Fig. 45), become filled with corpuscles (Fig. 46), and even the smallest capillaries pulsate. The blood in the veins adjacent to the area of inflammation is of a much lighter red than in health. Many capillaries which were invisible under normal conditions become visible when active hyperemia exists. The capillaries contain no muscle-fiber, and hence these tubes cannot actively contract, except so far as the caliber of the tubes is altered by the contraction or expansion of the endothelial cells of the capillary wall. Contraction and dilatation of the capillaries depend chiefly on the amount of blood sent to or retained in them. In active hyperemia the increased amount of blood sent to the part causes capillary dilatation. As a result of the dilatation the endothelial cells become thinner than before, the cells as a result of irritation lose some of their power to restrain exudation, and some observers assert that openings are formed between the cells or that previously existing openings enlarge (page 77). Fluid elements rarely leave the blood-vessels during active hyperemia, but they occasionally do. The wheals of urticaria are thus formed (Warren). Active hyperemia is often the first stage of an inflammation, but it is not of necessity followed by other inflammatory changes, and it can be caused by nerve section or nerve stimulation.

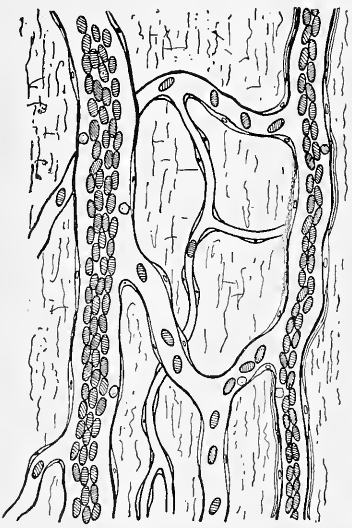


Fig. 45.—Normal vessels and blood-stream.

The duration of active hyperemia is variable. If the irritation was brief, the hyperemia is very transitory. In some cases dilatation with accelerated circulation is scarcely more than momentary, giving way almost immediately to dilatation with retardation. If the irritation is prolonged, hyperemia may last some time before giving way to retardation. In the web of a frog's foot, if an irritant is applied, hyperemia lasts from one-half hour to two hours before it is replaced by retardation.

Clinical Signs of Active Hyperemia.—A hyperemic part, if on or near the surface, is red in color, imparts a sense of heat to the examining hand, the color quickly disappears on pressure and quickly returns when pressure is released. In a congested part the temperature is diminished, the surface

is purple, the congested veins are visible, there are edema and a sensation of coldness and numbness. When congestion is purely local, the lividity disappears quickly when pressure is applied and returns quickly when pressure is removed. When due to disease of the heart or lungs, it disappears and returns slowly. When a local congestion is about to give way to gangrene, the lividity disappears very slowly on pressure and crawls back slowly when pressure is released.

Retardation.—After active hyperemia has existed for a variable time the blood-current begins to lessen in velocity, until it becomes more tardy than in health. This is known as "retardation of the circulation." Retardation is first noted in the venules, next in the capillaries, and last in the arterioles; but arterial pulsation continues. The red cells take the center of the blood-stream, which is known as the axial current. The white corpuscles drop out of the central stream, separate from the red, and float lazily along near the vessel-wall, and they are accompanied by many third corpuscles. The white cells show a strong tendency to adhere to the venule-walls, and, as a result, accumulate against the inside of, and stick to, these walls and to one another, until the venules are entirely lined with layers of *leukocytes* (Fig. 47). The third corpuscles act in a similar manner and take the peripheral current. In the capillaries some leukocytes gather, but not many. In the arterioles they adhere during cardiac dilatation, but are swept away by the force of the heart's contractions. Retardation is believed to be chiefly due to paresis of the muscular walls of the arterioles. This causation seems probable when we recall Lord Lister's experiments upon the pigment-cells of the frog's foot. Lister proved that inflammation paralyzes the pigment-cells, and concluded that dilatation at the focus of an inflammation is due to the paralyzing action of an irritant. Dilatation at a distance from the focus is a reflex phenomenon (W. Watson Cheyne). When the vessels are weakened or paralyzed, the contractions of the arterioles are feeble or absent, and the blood is no longer urged forward by arterial power. The endothelial cells of the small vessels enlarge distinctly during retardation and develop a condition of stickiness, which leads the white cells to adhere to them, and thus increases resistance to the current of blood and adds to retardation. Fluids pass through the wall of a vessel in this condition more readily than through a healthy vessel, and white corpuscles leave the vessel in large numbers.

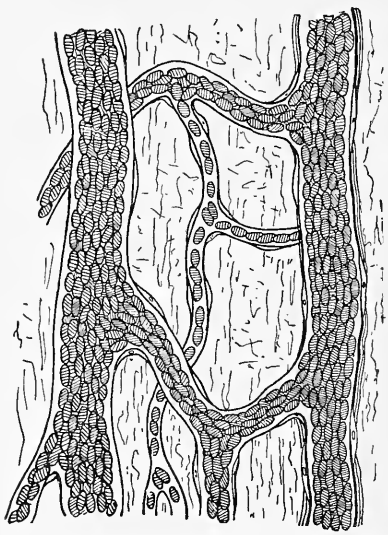


Fig. 46.—Dilatation of the vessels in inflammation.

Oscillation and Stagnation.—By this accumulation of leukocytes the blood-stream is progressively narrowed and the axial current is impeded. The red blood-cells begin to stick to one another, forming aggregations like

rouleaux of coin, which masses increase the difficulty the axial current has to contend with, until progressive movement ceases and the contents of the vessels sway to and fro with each heart-beat. This is the stage of *oscillation.* In a short time oscillation ceases and the vessels are filled with blood which does not move, and the vessel-walls become irregular in outline or even pouched. This stage is known as "stasis" or "stagnation." Stasis is chiefly due to paralysis and damage of the vessel-walls. Migration ceases when stasis takes place. If stasis persists, coagulation occurs, because the vessel-walls have been so injured by the irritant as to be practically dead material, and they are no longer able to prevent clotting of their contents. Finally, in persisting stasis the vessel-walls rupture or are entirely destroyed.

Résumé of the Vascular Changes of Inflammation.—We can sum up the vascular changes of inflammation by stating that they consist in a dilatation of the small vessels and a primary acceleration, a secondary retardation, and a subsequent stagnation of the blood-current, exudation of blood-liquor, adhesion of leukocytes to the walls of veins and capillaries, migration of leukocytes, the aggregation of the red blood-cells into intravascular masses, and coagulation of the material remaining in the vessel.

Fig. 47.—Retardation of blood and migration of white corpuscles in inflammation.

Exudation of Fluids.—It is to be remembered that in the process of nutrition blood-liquor and also white cells pass into the tissues through the walls of veins and capillaries, and during this process certain other materials are passing from the tissues into the vessels. Hence, a diffusible irritant in the vessels may pass into the tissues and a diffusible irritant in the tissues may pass into the vessels. Whenever retardation of the circulation arises, there is an increase in the amount of plasma which passes out of the vessels, but in inflammation the exudation into the lymph-spaces is vastly greater in amount and is different in composition. In a slight inflammation, and in the early stage of any inflammation, there is an increase in the fluid exudate, and we speak of the condition as "*serous inflammation.*" This fluid is really not serum, but is liquor sanguinis. We find true serum in passive congestion, not in active inflammation. The fluid in a serous exudation contains very few white cells, and hence little or no fibrin can form in it, and coagulation does not take place in the perivascular tissues; and if the inflammation goes no further, the exudate is absorbed by the lymphatics. A blister is an example of serous inflammation. If the inflammation continues to intensify, the exudation is altered in character—it becomes thicker, turbid, and very coagulable and exhibits a greatly increased bactericidal power. It contains many white cells and fibrin elements, and coagulates in the tissues, because some of the leukocytes

break up and set free fibrin ferment, and fibrin ferment causes the union of calcium and fibrinogen and the formation of fibrin. This fluid exudate is known as "*lymph*," or *plastic exudation*, and when it is present we speak of the condition as "*plastic inflammation*." Lymph can be seen in the anterior chamber of the eye in cases of plastic iritis. Coagulated fibrin in a recent wound causes the edges to adhere or glazes the raw surface. In inflammation of a mucous surface it may appear as a false membrane. In inflammation of serous surfaces it may glue the surfaces together and lessen motion, the fibrinous masses which effect the gluing being called fibrinous or plastic adhesions. These adhesions within the abdomen may seal a perforation, may cover a raw spot, or may encompass an area of infection and prevent fatal diffusion. Further fibrin surrounds and entangles bacteria and retards their diffusion. Pyogenic cocci lessen, retard, or prevent fibrin formation or destroy fibrin previously formed. The fibrinous adhesions may, of course, do harm. They may retard or prevent the absorption of exudate; they may narrow and obstruct important structures (bowel, urethra, larynx), they may bind up and cripple an important viscus (liver, heart or brain). Fibrinous adhesions may be succeeded by dense contracting and constricting bands of fibrous tissue. The lymphatics endeavor to absorb the fluid exudate in inflammation, but become occluded by coagulation, and the area they drain becomes swollen, hard, and "brawny." The slighter the inflammation, the less albuminous is the fluid; the more intense the inflammation, the more albuminous is the fluid. The focus of an inflammation usually feels brawny because of coagulation of a highly albuminous exudate; the periphery of an inflammation is soft and edematous because of the presence there of thin and non-coagulable exudate. Inflammatory lymph contains proteids and other substances. "Of these the more important are ferments, the results of proteolysis (notably fibrin and its precursors and peptones), and in many cases mucin, together with bactericidal substances, and, where bacteria are present, the products of their growth." * The amount of the exudation varies with the violence of the irritation, the nature of the irritant, the general condition of the organism, and the state of the tissues which are involved. In dense tissue (bone, periosteum, etc.) the exudation is scanty. In loose tissues (subcutaneous tissue) it is profuse. Profuse exudation may take place into a joint, the pleural sac, the peritoneal cavity, or the pericardium. In such cases the exudation is profuse because the serous membrane has a thin covering of endothelium, contains quantities of vessels, and the vessels receive but a thin covering and obtain but a scant support towards the cavity.

Does the plasma leave the vessels as a simple filtrate? Some maintain that it does. Heidenhain and others claim that it does not, and believe that the endothelial cells play an active part in the process. Heidenhain likens exudation to secretion, because some materials from the plasma pass out and others do not. Adami is inclined to agree with Heidenhain, that the epithelium plays "not a passive, but an active rôle." Are there spaces between the endothelial cells of the capillary? It was long taught positively that there are no open spaces between the endothelial cells of the vessel-wall, and that these cells are held close together by a cement substance. It is now believed by some observers that spaces exist between the protoplasmic strands which

* Adami, in Allbutt's "System of Medicine."

hold the cells together, these spaces being closed when the vessel is contracted and open when the vessel is dilated. When these spaces are open fluid passes, and through these doorways leukocytes emerge.

Migration and Diapedesis.—Even early in an inflammation some few white corpuscles pass through the vessel-walls; but when the inflammation is well established, large numbers, and when it is severe vast hordes, pass into the perivascular tissues. This process is known as "migration" (Figs. 47 and

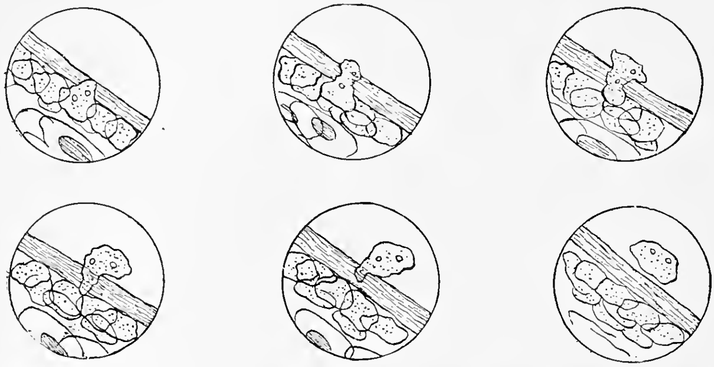


Fig. 48.—Stages of the migration of a single white blood-corpuscle through the wall of a vein (Caton).

48). The leukocytes throw out protoplasmic arms, insert themselves between the cells of the walls of the vessel, and pull themselves through by their power of ameboid movement (Fig. 49). Some observers claim that they do not pass through existing open doors, but form openings which close after them. This is readily accomplished, because the vessel-wall is itself damaged, weakened, and convoluted. Others claim that stomata exist between the endothelial cells, the vessel-wall being porous like a filter (page 77). The escape of leukocytes takes place chiefly from the venules, though some migrate through the capillaries and even the arterioles (Fig. 47).

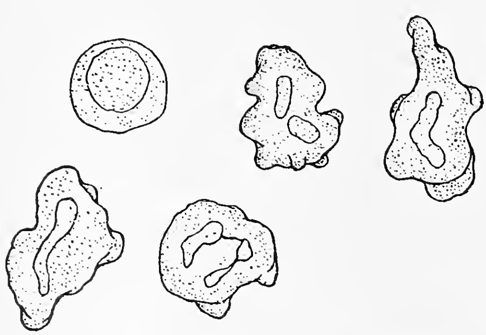


Fig. 49.—Ameboid movements of a leukocyte (Warner).

The leukocytes are influenced to move toward the damaged tissue by the attractive force known as *positive "chemiotaxis,"* a force which draws them toward invading bacteria, to regions of irritation, and to areas of tissue death. Leukocytes may move from very virulent organisms, influenced by what is known as *negative "chemiotaxis."* The migration of a leukocyte requires but a short time. Fig. 48 shows the migration of a white blood-cell through a vein-wall, the process requiring one hour and fifty minutes. In very acute inflammations red corpuscles also pass into the tissues. Red corpuscles are not

capable of ameboid movements, and if they do escape from the vessels the process is passive on their part and not active. This passive escape happens because the capillary walls have been destroyed or because stomata have been greatly enlarged by vascular dilatation. If red corpuscles do pass into the exudate, as happens in pneumonia, the inflammation is a very severe one and is called a hemorrhagic inflammation. The escape of corpuscles by a passive process is known as "diapedesis," in contra-distinction to the escape of leukocytes by active ameboid movements, a process known as "migration." The white corpuscles usually greatly increase in number in the blood of a person who has an acute inflammation, and the blood-making organs, such as the spleen and lymphatic glands, are often enlarged. An increase of white corpuscles in the blood of an individual is called *leukocytosis.*

Blood Plaques.—*Blood plates*, *blood plaques*, or *third corpuscles*, may be discovered in freshly drawn blood, but, unless they are present in unusual numbers, they will rarely be seen in specimens prepared in the usual way. The third corpuscles can be seen by a high power microscope in the moving blood of the web of a frog's foot. In blood outside of the body they are destroyed as soon as coagulation begins, and in order to see them coagulation must be prevented. Some observers maintain that the third corpuscles are the real fibrin-formers. The blood plaques, or third corpuscles, are found to be present in increased numbers in inflammation. In health their usual proportion to red cells is as 1 to 20. They are especially numerous at the height of fever processes and during convalescence from an extensive abscess.

Changes in the Perivascular Tissues.—The cells of the perivascular tissue are phagocytes and when stimulated they enlarge, become more actively phagocytic, and undergo reproduction. The liquor sanguinis which exudes during an acute inflammation coagulates unless prevented by virulent bacteria. It has often been asserted that exudation is Nature's method of supplying nutriment to the cells of the damaged region. Adami points out the apparently contradictory observation that the amount of exudate is in direct proportion to the rapidity of cell-destruction, but nevertheless concludes that exudation stands in close relation with cell-proliferation.* From whatever cause, tissue-cells multiply, and this process is known as "*cell-proliferation.*"

When a tissue is injured it inflames, and, as Adami points out, the reaction we call inflammation is an attempt to repair injury.

Irritation may lead to degeneration and death of cells; it may lead to growth and multiplication. In many cases both processes are active in the acute stage, the cells at the focus of the inflammation undergoing degeneration and destruction, and those at the boundary undergoing growth and proliferation.†

If tissue-cells have been seriously damaged, they perish, and new cells are required to replace them. The inflammatory process has led to exudation of plasma and migration of leukocytes into the perivascular tissues. The connective-tissue cells multiply and produce young cells, which are known as "*fibroblasts,*" and which eat up many leukocytes. Early in an inflammation polynuclear leukocytes preponderate, later mononuclear phagocytic cells

* Adami, in Allbutt's "System of Medicine."

† Adami, in Allbutt's "System of Medicine."

predominate (Opie). The leukocytes contain two enzymes. One is derived from bone marrow and digests proteid in an alkaline medium; the other is derived from lymph-glands and digests proteid in an acid medium (Opie). The migrated leukocytes in part surround the inflamed region and retard diffusion of the process. Many enter the diseased area and attack bacteria. Some undergo degenerative changes and liberate fibrin ferment which makes the exudate clot. Some move out of the inflamed area, each one carrying within it tissue débris, and many are eaten up by the fibroblasts. There is no real proof that leukocytes proliferate and help directly to form new tissue. This mass of young cells, taking origin from the fixed cells, has been called *embryonic tissue*, because of a fancied resemblance to the cells of the embryo. John Hunter called it *juvenile tissue.* It has also been called *indifferent tissue*, because of the belief that it could be converted indifferently into various tissue according to circumstances. It is also spoken of as *inflammatory new formation.*

An exudation may be absorbed by the lymphatics. It may be converted into pus if infected with pyogenic bacteria, or be replaced by cells from the proliferation of fixed tissue-cells, the cellular mass being subsequently vascularized by the extension into it of capillary loops derived from adjacent capillaries. When embryonic tissue is filled with blood-vessels,—that is to say, when it is vascularized,—it is called *granulation tissue.* Granulation tissue is finally converted into fibrous tissue. The above complicated processes, vascular and perivascular, are not accidents nor haphazard freaks, but are Nature's efforts to bring about a cure.

Dilatation is due to the direct effect of the irritant upon the muscle or its nerve-elements. Retardation and stasis are due to paralysis of the vessel-wall, which paralysis causes resistance to the passage of the blood-stream and adhesion of the leukocytes to the vessel-wall. The blood-liquor exudes and the leukocytes migrate. Often these efforts of Nature succeed. Acceleration of the circulation may succeed in washing away an irritant from the vessel-wall. By bringing quantities of blood to the part it secures copious exudation of plasma. The exudation may wash and remove irritants from the tissues, and the germicidal blood-liquor may destroy bacteria in the damaged area. The migration of corpuscles may prove of great service. The leukocytes surround an area of infection and tend to limit its spread. Leukocytes have phagocytic properties, and energetically attack and often destroy bacteria, and they furnish enzymes which may digest proteids and antitoxins which antagonize and may neutralize the poisons produced by micro-organisms. Leukocytes aid in forming fibrin. Fibrin formation is of service by helping immobilization and by hindering the spread of bacteria. Leukocytes also aid in separating dead tissue from living, and they remove tissue débris from the area of inflammation. The multiplication of the fixed connective-tissue cells leads to the formation of fibroblasts, and fibroblasts are converted into fibrous tissue, which effects permanent repair (these changes will be alluded to again in the section on Repair).

Nature may fail in her efforts. For instance, an enormous exudate increases stasis and may cause such tension that gangrene results.

Inflammation in Non-vascular Tissue.—A type of non-vascular tissue is the cornea, and the cornea can inflame. The healthy cornea contains

no blood-vessels. It is formed of many layers of fibers, each layer running parallel with the corneal surface and forming angles with the fibers of the adjacent layers. Between the layers are communicating lymph-spaces containing connective-tissue cells known as corneal corpuscles. It obtains its nourishment in part from the vessels of the conjunctiva, but chiefly from the vessels of the ciliary body and sclera. When the cornea inflames, the episcleral, conjunctival, and ciliary vessels usually dilate and pour out exudate, and the fluid exudate and the leukocytes enter into the corneal lymph-spaces. The exudate coagulates and cell-multiplication ensues as in any other inflammation. In mild inflammations the vessels about the cornea may not dilate. Leukocytes, from the lymph-spaces, reach the seat of injury in small numbers, and the fixed cells multiply. Nancrede points out that in trivial inflammation which injures but does not destroy the epithelium leukocytes may not go to the seat of inflammation, the only change being enlargement and multiplication of corneal corpuscles. If new formation takes place, a permanent opacity mars the cornea as a consequence.

Cartilage has no blood-vessels except in regions where growth is very active or where ossification is taking place. Cartilage has no spaces, like the cornea, for a free circulation of lymph. In man canals have not been demonstrated and it is thought that fibrils conduct nutritive fluids, the nutritive plasma flowing between the cells, but there is no direct connection with blood-vessels. The plasma is furnished by the vessels at the margin of the perichondrium. Cartilage can inflame and an inflammation of this structure is slow in evolution and of long duration. When inflammation occurs, the cartilage cells enlarge and their nuclei proliferate, the intercellular substance softens and cartilage cells may be cast off. After a long time vessels may invade the inflamed cartilage and fibrous tissues form from the perichondrium, but in some cases a loss of substance is not repaired.

Inflammation of Mucous Membrane.—It may be catarrhal, suppurative, croupous, or diphtheritic. In a *catarrhal inflammation* the increased blood-supply causes an excessive flow of mucus. The submucous tissues present the ordinary changes of inflammation and quantities of epithelial cells are cast off from the surface. Fibrous tissues may form in the submucous tissue and thus cause permanent thickening (strictures, etc.).

Suppurative inflammation is usually preceded by catarrhal inflammation. In this condition the discharge is mucopurulent and ulcers are apt to form. A trivial loss of substance permits of regeneration, but a considerable loss is repaired by fibrous tissue which by its bulk and by contracting may interfere greatly with the functional usefulness of an organ or a canal.

A *croupous inflammation* is one in which quantities of epithelial cells are cast off the surface and there forms upon the surface a highly fibrinous exudate (false membrane).

In *diphtheritic inflammation* the mucous membrane is destroyed and the false membrane invades the submucous tissue. Diphtheritic inflammation is due to a specific bacillus.

Classification of Inflammations.—The various forms of inflammations are—(1) *Simple* or *common*, that which is due to any ordinary traumatic, chemical, thermal, or actinic cause, and not to bacteria, such as traumatic periostitis or sun dermatitis. It does not tend particularly to spread. As a

rule, the cause of a simple inflammation is momentary in action; (2) *infective* or *specific*, that which is due to micro-organisms, as the streptococcus of erysipelas. An unsuccessful attempt has been made to charge all inflammations to bacteria. It is true that bacteria can generally be found in inflammatory areas, but that they are the only causes of inflammation is accepted by few. Infective inflammations often tend to spread widely; (3) *traumatic*, which is due to a blow or an injury; (4) *idiopathic*, which is without an ascertainable cause. There is certainly a cause, even if it cannot be pointed out, and the term "idiopathic" means that we do not know the cause; (5) *acute*, which is rapid in course and violent in action; (6) *chronic*, which follows a prolonged course; (7) *subacute*, which is intermediate in violence and duration between acute and chronic; (8) *sthenic*, characterized by high action. Occurs in strong young subjects; (9) *asthenic* or *adynamic*, occurring in the old, the debilitated, and the broken-down. In such an inflammation there is no certain limitation of the inflammation by leukocytes, and there is an indisposition on the part of the tissue-cells to form fibroblasts; (10) *parenchymatous*, affecting the "parenchyma," or active cells of an organ; (11) *interstitial*, affecting the connective-tissue stroma of an organ; (12) *serous*, characterized by profuse non-coagulating exudation (as in pleuritis) or by marked inflammatory edema; (13) *plastic*, *adhesive*, or *fibrinous*, characterized by an exudation which glues together adjacent surfaces, as in peritonitis; (14) *purulent*, *phlegmonous*, or *suppurative*, when pyogenic cocci are present and multiply; (15) *hemorrhagic*, when the exudate contains many red blood-cells, as in strangulated hernia and in the pustules of black smallpox; (16) *croupous*, when an inflammation produces upon the surface of a tissue a fibrinous exudate which cannot be organized into tissue, and which is due to the action of micro-organisms. An exudate of this character was called by the older surgeons "*aplastic lymph*." It occurs most usually on mucous membrane; (17) *diphtheritic*, which differs from croupous in the fact that the false membrane is in the tissue rather than upon it; (18) *gangrenous*, an inflammation resulting in death of the part, the gangrene being due to the tension of the exudate or the virulence of the poison; (19) *healthy*, when the tendency is to repair; (20) *unhealthy*, when the tendency is to destruction; (21) *latent*, an inflammation which for some time does not announce itself by any obvious symptoms, as the inflammation of Peyer's patches in typhoid fever; (22) *contagious*, when its own secretions can propagate it; (23) *dry*, without exudation; (24) *hypostatic*, arising in a region of passive congestion (as a bed-sore); (25) *malignant*, due to a malignant growth; (26) *catarrhal*, affecting a mucous membrane; (27) *neuropathic*, due to impairment of the trophic functions of the nervous system, as in perforating ulcer; and (28) *sympathetic* or *reflex*, due to disease or injury of a distant part, as when orchitis follows mumps.

Extension of Inflammation.—Inflammation extends by continuity of structure, by contiguity of structure, by the blood, and by the lymphatics. Extension by continuity is seen in phlebitis. Extension by contiguity is seen when a cutaneous inflammation advances and attacks deeper structures. Extension by the blood is seen in the formation of the smallpox exanthem. Extension by the lymphatics is witnessed in a bubo following chancroid.

Terminations of Inflammation.—Inflammation may be followed by a return of the tissues to health, and this return may take place by delitescence, by resolution, or by new growth. By *delitescence* is meant abrupt termination at an early stage, as when a quinsy is aborted by the administration of quinin and morphin, and the production of a sweat; *resolution* means the gradual disappearance of the symptoms when inflammation has passed through its regular stages; and *new growth* means that an inflammation has lasted a considerable time, with ample blood-supply, and without suppuration and has gone on to the formation of fibroblasts, granulation tissue, and fibrous tissue. Inflammation may be followed by death of the inflamed part, or necrosis. Death of the part may be due to suppuration, ulceration, or gangrene.

The **causes of inflammation** are—*predisposing*, or those residing in the tissues, and rendering them liable to inflame; and *exciting*, or those which directly awake the process into activity. The first may be thought of as furnishing inflammable material; the second may be regarded as sparks of fire.

Predisposing causes are those which impair the general vigor, injure the blood, weaken the tissues, or lower nutritive activities. Among these causes are shock, hemorrhage, nervous irritation, gout, rheumatism, diabetes, Bright's disease, alcoholism, and syphilis. Plethora renders a person liable to sthenic inflammations (those characterized by high action). Tissue debility renders one prone to adynamic or asthenic inflammations. Nerve injury predisposes to inflammation, either from damage to trophic nerves and consequent failure in tissue nutrition and resistance or because analgesia exists and irritants which reach the region are not recognized and are allowed to remain. For instance, if the conjunctiva is in a condition of analgesia, the presence of foreign bodies is not noticed and destructive inflammation may result from their non-removal.

After removal of the Gasserian ganglion the cornea is devoid of sensation, the flow of tears is lessened, dust gathers in the eye, and if not removed by irrigation or kept out by a shield inflammation and disastrous ulceration will ensue.

Exciting Causes.—The exciting causes of inflammation are—*traumatic*, as blows and mechanical irritation; *chemical*, as the stings of insects, the rubefacient effects of mustard, venom of serpents, products of bacteria, ivy poison, etc.; *thermal*, heat and cold; *specific*, the micro-organisms, causing, for instance, tuberculous peritonitis or erysipelas; and *nervous*, nerve stimulation certainly being capable of producing hyperemia and sometimes even inflammation. Inflammation due to nerve stimulation is seen in herpes zoster and in the swollen and discolored skin over an inflamed joint (Adami). Inflammation may also be induced by electric currents, by the *x*-rays, by radium rays, and by the actinic rays of sunlight and of electric light.

Some writers insist that every inflammation is due to the action of micro-organisms, but this statement lacks proof. They maintain that inflammation is a destructive microbic process which cannot bring about repair, and that repair begins only when inflammation ends. As Adami points out, the advocates of this view argue that swelling, pain, and discoloration point to the existence of inflammation; that repair can take place when these phenomena

are absent, hence inflammation is not present when repair begins. As a matter of fact, swelling, discoloration, and pain are phenomena often but not invariably associated with inflammation; and in inflammation one or all of these phenomena may be absent. Because these signs are not discovered is no proof that inflammation does not exist. I believe that inflammation is not always due to microbes and is not always a destructive process, but may be from the start conservative and reparative. It is the reaction of the tissue to injury and is the first step on the road to repair.*

Symptoms of Acute Inflammation.—Inflammation, if at all severe, announces its presence by symptoms which are both *local* and *constitutional*. The local symptoms are heat, pain, discoloration, swelling, disordered function, and in some regions muscular rigidity; the chief constitutional symptom is fever.

Local Symptoms of Inflammation.—The most prominent local symptoms were known centuries ago to the famous Roman, Celsus, who stated them as "*rubor, calor cum tumore et dolore*"—redness and heat with swelling and pain. As set forth to-day, the local symptoms are—(1) heat; (2) pain; (3) discoloration; (4) swelling; (5) disordered function; and (6) muscular rigidity, which is noted in inflammation of certain regions and structures.

Heat is due to the passage of an increased quantity of blood through the damaged area and to the arrival at the surface of the body of warm blood from internal parts. Although an inflamed part may be, and usually is, warmer than the surrounding parts, its temperature is never greater than the temperature of the blood. This increase of heat is especially noticeable when we, for instance, touch an arm affected with erysipelas and contrast the sensation obtained with that obtained by placing the hand on the sound arm. The diseased arm feels much warmer to the examining hand than does the sound arm, but its temperature is not above the general body-temperature. An extremity in health, as is well known, shows on the surface a temperature below that of the blood; in an inflamed state the temperature may nearly equal that of the blood. Heat is always present in inflammation of a superficial part. The surgeon examines for heat by placing his hand upon the suspected area and then placing it upon a corresponding portion of the opposite side of the patient in order to note the contrast. If great accuracy is desired, a surface thermometer is used.

Pain is a constant and conspicuous symptom. It is due to stretching of or pressure upon nerves from exudate; to irritation of nerves; or to inflammation of the nerves themselves, producing cellular changes. Pain is associated with *tenderness* (pain on pressure), it is aggravated by motion and by a dependent position of the part, and it varies in degree and in character. In serous membranes it is acute and lancinating, like dagger-thrusts; in connective tissue it is acute and throbbing; in large organs it is dull and heavy; in the bone it is gnawing or boring; in the skin and mucous membrane it is itching, burning, smarting, or stinging; in the urethra it is scalding; in the testicle it is sickening or nauseating; in the teeth it is throbbing; and in inflammation under dense fascia it is pulsatile. Pain in inflammation after presenting itself in one form may change in character. If a pain becomes markedly throbbing, suppuration may be anticipated. Pain does not always occur at the seat of trouble, but may be felt at some distant point. This is

* See Adami's masterly article in Allbutt's "System of Medicine."

known as a "*sympathetic*" *pain*, and is due to the fact that the area to which pain is referred receives its nerve-supply from the same spinal segment as does the inflamed area, in other words, there is a nervous communication between the inflamed part and a distant area. In most cases of sympathetic pain a nerve-trunk refers the sense of pain to its peripheral distribution but sometimes pain is referred to an adjacent nerve, a distant nerve, or even, perhaps, to a nerve on the opposite side of the body. Tenderness, however, is detected at the seat of trouble and not at the seat of referred pain.

Pain of hepatitis is often felt in the right shoulder. Pain at the point of the shoulder or in the shoulder-blade is felt also in gall-stones and in cancer of the liver. The pain arises in filaments of the pneumogastric from the hepatic plexus, which filaments reach the spinal accessory, pain being expressed in the branches of the spinal accessory which supply the trapezius and communicate with the third and fourth cervical nerves.*

Pain of coxalgia is often felt on the inside of the knee, because the obturator nerve, which sends a branch to the ligamentum teres, also sends a branch to the interior and to the inner side of the knee-joint.

Inflammation of an eye with increased tension causes browache. *Inflammation of the neck of the bladder* causes pain in the head of the penis. *Inflammation of a testicle* cause pain in the groin. *Renal calculus and pyelitis* cause pain in and retraction of the testicle, and pain in the loin, groin, or thigh.

If the covering of an organ is involved, pain becomes more violent; for instance, hepatitis becomes much more painful when the perihepatic structures are attacked. Inflammation without pain is known as "latent" (as the inflammation of Peyer's patches in typhoid). The sudden disappearance of inflammatory pain, when not due to the administration of opiates, suggests the possibility of gangrene, because analgesia exists in gangrene. The characteristics of inflammatory pain are that it comes on gradually, has a fixed seat, is continuous, is attended by other inflammatory symptoms, and is increased by motion, by pressure, and by a dependent position of the part. If there be no tenderness in a part, the source of the pain is not local inflammation; but tenderness may exist when there is no local inflammation, as in pain referred from a distant part. Pain of inflammation does not correspond to an exact nervous distribution. If pain corresponds exactly to the area of a nerve's distribution, the cause of it is acting on the nerve-trunk or on its roots. If the cutaneous surface is involved, the lightest touch causes pain. If touching the skin produces no pain, but deep pressure does produce it, the deeper structures are the source. Pain in muscle and ligament is developed by motion; in muscle, by contraction, but not by passive movements with the muscle relaxed; in ligament pain is developed by active or passive movements which stretch the ligament. If, for example, a man with a stiff neck has pain on the right side of the back of his neck on voluntarily turning his face toward the left shoulder, but is without pain when his face is turned by the surgeon, who, conversely, induces pain by turning the patient's face far to the right, this condition indicates the trouble to be muscular. If, however, no pain arises on turning the face to the right, but it is manifest on turning the face actively or passively to the left, the pain is in those ligaments which stretch

*Embleton's view in Hilton on "Rest and Pain," a book every student should read.

when the face is turned to the left.* In inflammation of the synovial membrane gentle passive motion in any direction causes pain.

The pain of colic differs from that of inflammation. It is sudden in onset, intermits, recurs in paroxysms, and is relieved by pressure. The pain of inflammation is gradual in onset, is continuous, and is made worse by pressure. The pain of neuralgia is often preceded by cutaneous anesthesia of the skin of the part, is very paroxysmal, comes on suddenly, darts through recognized nerve-areas, the attack lasts some hours, and is apt to recur at a certain hour. It presents no general tenderness, as does inflammation, but we may find serveral points which are acutely sensitive to pressure (Valleix's *points douloureux*). The tender spots of Valleix are met with in *inveterate* neuralgia, and occur at points where nerves "pass from a deeper to a more superficial level, and particularly where they emerge from bony canals or pierce fibrous fasciæ."†

Pain is often of great value by calling attention to parts diseased; but it may be a terrible evil, racking the organism and even causing death. If pain continues long, it becomes in itself formidable: it prevents sleep, it destroys appetite, and it deteriorates the mind, and one of the surgeon's highest duties is to relieve it. The *physiognomy or expression of physical pain* presents the following characteristics: Heavy fulness about the eyes, and dropping of the angles of the mouth, added to appearance due to anemia, widespread tremor, etc. The absence of the physiognomy of pain in a person who complains of great agony is a strong indication that the patient exaggerates the gravity of his sufferings or deliberately deceives.

Discoloration arises from determination of blood to the part; hence the more vascular the tissue, the greater the discoloration. A non-vascular tissue presents no discoloration, though we usually find discoloration adjacent in the zone of blood-vessels which furnish the tissue with nutriment. Discoloration is most intense at the focus or center of inflammatory action. Discoloration varies in tint and in character according to the tissue implicated and the nature of the inflammation. It may be circumscribed or diffuse. Arborescent redness means a distribution in dendritic lines. Linear discoloration signifies redness running in straight lines, as in phlebitis. Punctiform discoloration occurs in points, and is due to vascular rupture. Maculiform redness resembles an ecchymosis or blotch. Dusky discoloration points to suppuration.

Inflammation of the throat and skin produces scarlet discoloration; inflammation of the sclerotic coat of the eye and of the fibrous coat of muscle produces lilac or bluish discoloration; inflammation of the iris produces brick-dust, grayish, or brown discoloration; erysipelas causes a yellowish-red discoloration; secondary syphilis causes a copper-hued discoloration; and tonsillitis causes a livid discoloration. A tuberculous ulcer is of a purple color on the edge. Gangrene is shown by a black discoloration. A scorbutic ulcer is surrounded by an area of violet color.

Redness as a sign of inflammation must be permanent and joined with other symptoms. Redness due to inflammation disappears on pressure, but returns as soon as the pressure is removed. If redness is due to staining of the surface by dye, pigmentation, or extravasation of blood, pressure will not

* "Surgical Diagnosis," by A. Pearce Gould.

† Anstie, "Neuralgia and Diseases which Resemble It."

blanch the spot. If on taking off pressure the redness of inflammation rapidly returns, the circulation is active; if, on the contrary, it very slowly reappears, the circulation is very sluggish and gangrene is threatened. Subcutaneous hemorrhage gives rise to a purple-red color which does not fade when subjected to pressure. Stains of the surface by dyes fail to disappear on pressure, are distributed over a considerable surface, show a hue which is uniform throughout, are obviously superficial, are not associated with other signs of inflammation, and can be washed away.

A. Pearce Gould, in his excellent little work upon "Surgical Diagnosis," tells us that the color of a hyperemic surface may furnish important information. Lividity may mean failure of the heart and lungs, or simply venous congestion in the part. In lividity from obstruction of the lungs or heart the color slowly returns after pressure has driven it out. In lividity due to local congestion the color quickly returns when pressure is released and the dilated veins are often distinctly visible. Of course, in a local trouble, when the circulation becomes impaired to such a degree that gangrene is threatened, the lividity fades very slowly on pressure and reappears very slowly on the release of pressure.

Swelling or *tumefaction* arises in small part from vascular distention, but chiefly from effusion and cell-multiplication. The more loose cellular material a part contains, the more it swells; hence the eyelids, scrotum, vulva, tonsils, glottis, and conjunctivæ swell very largely when inflamed. A swelling is soft or edematous when due to uncoagulable effusion; is brawny and doughy when due to coagulated effusion; is hard and elastic when produced by proliferating cells. Swelling may do good by unloading the vessels and acting like a blister or local bleeding, or it may do great harm by pressing upon the vessels and cutting off the blood-supply. Swelling of the conjunctiva, or chemosis, may cause sloughing of the cornea, and swelling of the prepuce may cause gangrene. A swelling may do harm by obstructing a natural passage, as in edema of the glottis, when the larynx becomes blocked; or by compression of a normal channel, as in the swelling of the perineum, when the urethra is compressed. A swollen area may be covered with blisters or blebs. This condition is noted particularly in burns and fractures.

Disordered function is always present in inflammation. It may be manifested by *increased tenderness* or sensibility, a slight touch, it may be, producing torturing pain. Parts almost or entirely destitute of feeling when healthy (as tendons, ligaments, and bones) become highly sensitive when inflamed. It may be manifested by *increased irritability*. In dysentery the colon repeatedly contracts and expels its contents; the stomach does likewise in gastritis; and the bladder acts similarly in cystitis. Spasmodic twitching of the eyelids occurs in conjunctivitis, and twitching of the muscles of a limb in fracture and after amputation.

Impairment of Special Function.—In inflammation of the eye, when an attempt is made to look at objects, the lids close spasmodically, and even a little light causes great pain and lachrymation (photophobia). In inflammation of the ear noises cause great suffering, and even when in a quiet room the patient has subjective buzzing and roaring in his ears (tinnitus aurium). In coryza the sense of smell, in glossitis the sense of taste, in dermatitis the sense of touch, and in laryngitis the voice may be lost. In inflammation of

the brain the mind is affected; in arthritis the joints can scarcely be moved; and in myositis it is difficult and painful to employ the muscles.

Derangement of Secretions.—In dermatitis the sweat it not thrown off; in hepatitis bile is not properly secreted; and in nephritis urea is not satisfactorily removed. The secretions may undergo important changes of composition. The sputum in pneumonia is rusty, and dysentery causes a discharge of bloody mucus (Gross).

Derangement of Absorbents.—In the height of an inflammation the absorbents are blocked and clogged by coagulated exudate, and they cannot perform their offices.

Muscular rigidity is sometimes an important sign of inflammation. If a joint is inflamed the muscles which move the joint are rigid and the joint is more or less immobile. In inflammation of the peritoneum the abdominal muscles are rigid and the respirations become shallow, frequent, and thoracic. In pleuritis the intercostal muscles of the inflamed side become rigid and the respiratory excursion of the chest is limited. Rigidity serves to lessen motion, prevent pain, protect the part, and so give physiological rest.

Constitutional symptoms of acute inflammation may be absent, and often are in moderate or limited inflammations; but in severe, extensive, or infective inflammations the symptom group known as *fever* is certain to exist. This is known as *symptomatic*, or *inflammatory fever*, and it arises in non-septic cases from the absorption of aseptic pyrogenous exudate and in microbic inflammations from the absorption of pyrogenous toxic products of bacterial action. In young and robust individuals an acute non-microbic inflammation causes a fever characterized by full, strong pulse, flushed face, coated tongue, dry skin, nausea, constipation, and possibily acute delirium (the *sthenic type* of the older authors). In broken-down and exhausted individuals an ordinary inflammation, and in any individuals a bacterial inflammation, may cause a fever with typhoid symptoms (the *typhoid, asthenic*, or *adynamic type*). Fibrin ferment is obtained from the white corpuscles; it is liberated as the corpuscles break up in the exudate, and acting on the liquor sanguinis cause the union of calcium and fibrinogen and the formation of fibrin. The absorption of fibrin ferment many believe causes aseptic fever (page 124). Inflammatory blood contains an increased amount of albumin and salts. If a person with inflammatory fever is bled, the blood coagulates rapidly, the clot sinks, and there is found on the surface a cup-shaped coat, made up of liquor sanguinis and white cells, known as the "*buffy coat*"; but this is not really a sign of inflammation, and occurs normally in the blood of the horse. The buffy coat forms when blood contains a great number of leukocytes, because these leukocytes sink more slowly than do the red corpuscles. Cupping occurs because the white corpuscles sink more slowly by the side of the tube than far from the sides.

Leukocytosis.—In many inflammatory and infectious diseases leukocytosis is noted. It probably indicates an attempt on the part of the organism to protect itself from noxious materials. Leukocytosis is usually much more marked if pus exists than if the exudation is serous or fibrinous.

"The degree of leukocytosis may be considered a general index to the intensity of the infection and to the strength of the individual's resisting powers in reacting against it. If follows, therefore, that intense infections occurring

in individuals whose resisting powers are strong, produce a decided increase; but the presence of an infection of like intensity in one whose resisting powers are greatly crippled fails to cause leukocytosis, for in such an instance the organism is so overpowered by the effects of the morbid process that it is incapable of reacting." ("Clinical Hematology," by J. C. DaCosta, Jr.)

Chronic Inflammation.—This condition results from the action on the tissues of some mild but long acting irritant. It progresses slowly and does not produce symptoms of severity either in the part or the body at large.

Causes.—Blood diseases, as rheumatism and gout; infective diseases, as tuberculosis and syphilis; retained pus in an ill-drained abscess; blocking of the duct of a gland; the retention of a foreign body in a part; the flow of an irritant secretion (as saliva from a fistula); repeated identical traumatisms of an occupation, etc. W. Watson Cheyne tells us that chronic inflammation is not due to the ordinary pyogenic organisms (see Cheyne's article in Treves's "System of Surgery").

Tissue-changes.—These changes are practically the same as in acute inflammation, but take place far less rapidly. Vascular dilatation, exudation, and leukocytic migration are often trivial. Cell proliferation is always conspicuously marked. It is maintained by Cheyne and others that typical granulation tissue does not form, the tissues of the part being replaced directly by fibrous tissue. The amount of fibrous tissue produced is relatively very great. This tissue may cause permanent thickening, or may contract and thus diminish the size of a part. Contraction is very considerable in cirrhosis of the liver and in interstitial nephritis.

Symptoms.—Pain varying in intensity and character; tenderness; great swelling, which in some cases is followed by shrinking, and is usually indurated or brawny. As a matter of fact, great swelling is the most usual symptom. Sometimes there is a trivial amount of heat. There is rarely discoloration unless the skin is itself inflamed, but usually the surface veins are distinctly and sometimes they are greatly distended. There are no constitutional symptoms attributable purely to the inflammation. If there are such symptoms, they are due to the disease which induced the inflammation or to interference with the function of an organ because of the fibrous mass. (For the treatment of chronic inflammation see articles upon special regions and particular structures.)

Treatment of Acute Inflammation.—The first rule in treating an inflammation must be to remove the exciting cause. If this cause is a splinter in the part, take out the splinter; if it is a foreign body in the eye, remove the foreign body; if urine is extravasated, open and drain; take off pressure from a corn; pull out an ingrown nail; and remove microbes from an infected area by exposing, irrigating, and applying antiseptics. The rule, remove the cause, applies to a chronic as well as to an acute inflammation. If the cause of an inflammation was momentary in action (as a blow), we cannot remove it, for it has already ceased to exist. After removing the cause, endeavor to bring about a cure by local and constitutional treatment.

Local Treatment of Inflammation.—It must be remembered that the division of inflammation into stages is natural, and not artificial, and that a remedy which does good in one stage may do harm in another. Certain agents are suited to all stages of an acute inflammation, namely, *rest* and *elevation.* In

many inflammatory conditions Nature seeks to immobilize, protect, and rest the part by increasing the tension of adjacent muscles. By this muscular rigidity inflamed joints are fixed and rested. Rigidity of the intercostal muscles in pleuritis limits chest motion and pain; rigidity of the abdominal muscles in peritonitis limits abdominal movements and lessens suffering.

Rest.—Physiological rest is of infinite importance, and is always indicated in acute inflammation. In the exercise of function blood is taken to a part and an existing inflammation is aggravated. Further, as Billroth has pointed out, rest prevents the dissemination of infection, because motion exposes fresh surfaces to inoculation and breaks down protective barriers of leukocytes. Its principles were first thoroughly studied by Hilton.* Baron Larrey, the celebrated military surgeon of the Napoleonic Empire, anticipated many modern views on this subject. He insisted on the necessity of rest in the treatment of wounds; he believed that rest permitted Nature to perform her work unhampered; he was accustomed to leave a "first dressing," if properly applied, undisturbed for several or even for many days. He believed it advisable to associate with rest well adjusted and judicious compression made by bandages, especially flannel bandages. (The author on Baron Larrey, in "Johns Hopkins Hospital Bulletin," July, 1906.) The means of securing rest differ with the structure or the part diseased. When rest is used, do not employ it too long. *Rest in bed* diminishes the amount of blood sent to an inflamed part and lessens the force of the circulation; hence it antagonizes stasis. It has been shown that the heart beats at least fifteen times per minute less when the patient is recumbent than when he is erect. The saving of strength and the benefit to the local condition are thus seen to be enormous. In fact, the heart saves at least twenty-one thousand beats a day. In every severe inflammation insist on the patient going to bed.

In *cerebral concussion* rest must be secured by quiet, by darkness, by the avoidance of stimulants and meat, by the application of ice to the head, and by the use of purgatives to prevent reflex disturbance and the circulation of poisons in the blood. In *inflamed joints* rest must be obtained by proper position, associated in many cases with the adjustment of splints or plaster-of-Paris, or the employment of extension.

In *pleuritis* partial rest can be secured by strapping the affected side with adhesive plaster or by using a bandage or a binder to limit respiratory movements. In *fractures* Nature procures rest by her splints—the *callus*—and the surgeon procures rest by his splints—firm dressings, or extension. In *cancer of the rectum* and intractable rectitis a colostomy secures rest for the inflamed and damaged bowel. In *enteritis* opium gives rest to the bowel by stopping peristalsis. In *cystitis* rest is obtained by the administration of opium and belladonna, which paralyze the muscular fibers of the bladder. The use of the catheter gives rest to the bladder by removing urine. A cystotomy allows complete rest by permitting the bladder to suspend its function as a reservoir of urine. In cystitis from *vesical calculus* rest is obtained by cutting or crushing the stone. In *inflamed mucous membrane* rest from the contact of irritants is secured by touching the membrane with silver nitrate, which forms a protective coat of coagulated albumin. Opening an *abscess* gives its walls rest from tension. In *inflammations of the eye* light must be excluded to obtain complete rest, but tolerably satisfactory rest is given in some cases

* "Lectures upon Rest and Pain."

by the use of glasses of a peacock-blue tint. In *aneurysm* the operation of ligation cuts off the blood-current and gives rest to the sac. In *hernia* the operation gives rest from pressure. Instances of the value of rest could indefinitely be multiplied.

Relaxation is in reality a form of rest, and consists in placing the part in an easy position. In *synovitis* of the knee semiflexion of the knee-joint lessens the pain. In *muscular inflammations* relaxation relieves the pain.

Elevation.—Elevation partly restores circulatory equilibrium. A *felon* is less painful when the hand is held up in a sling than when it is dependent. A *congestive headache* is worse during recumbency. A *gouty inflammation* in the great toe is more painful with the foot lowered than when it is raised. A *toothache* becomes worse on lying down.

Certain agents are suited to the stage of vascular engorgement, increased arterial tension, and beginning effusion. These agents are—(1) local bleeding or depletion; (2) cutting off the blood-supply; and (3) cold.

Local Bleeding.—Local bleeding, or *depletion*, is the abstraction of blood from the inflamed area. This abstraction relieves circulatory retardation and causes the blood to move rapidly onward; the corpuscles clinging to the vessel-walls are washed away, the capillaries shrink to their natural size, and the exudate is absorbed. In other words, local blood-letting increases the rate of the circulation, though not its force.

The methods of bleeding locally are—(*a*) puncture; (*b*) scarification; (*c*) leeching; and (*d*) cupping.

Puncture is recommended in inflammation, not only because it abstracts blood locally, but also because it gives an exit to effusion under fibrous membranes. It is very useful in relieving tension—for instance, in epididymitis. It is performed with a tenotome and with aseptic precautions. If numerous punctures are made, the procedure is termed "multiple puncture." This is very useful when applied to the inflamed area around a leg-ulcer. The late Prof. Joseph Pancoast was very fond of employing multiple punctures, designating the operation "the antiphlogistic touch of the therapeutic knife."

Scarification or Incision.—By means of scarification we bleed locally, evacuate exudate, and relieve tension. One cut or many cuts may be made, and these cuts may be deep or may not go entirely through the skin, according to circumstances. Multiple incisions are useful when applied to inflamed ulcers, ulcers in danger of gangrene, and to almost any condition of great tension. Scarification is of notable value when edema of the glottis exists. Free incision is of great benefit in periostitis and in threatened gangrene. In osteomyelitis the medullary canal must be promptly opened.

Leeching.—Leeches must not be applied to a region plentifully endowed with loose cellular tissue, as great swelling and discoloration are sure to ensue. These regions are the prepuce, labia majora, scrotum, and eyelids. Leeches should never be applied to the face (because of the scar), near specific sores or inflammations, nor over a superficial artery, vein, or nerve. A leech is best applied at the periphery of an inflammation and between an inflammation and the heart. To leech at the inflammatory focus only aggravates the trouble. Before applying leeches, wash the part and shave it if hairy. Place the leech in a test-tube or an inverted wine glass, inserting the tail or thick end first, and invert the tube so that the leech's head will come in contact with the pre-

pared skin. The leech is restrained in the tube until it "takes hold" and begins to feed, when the tube is removed. If the leeches will not bite, smear the part with milk or a little blood. Never pull off a leech; let it drop off. It will usually drop off when full, but if it refuses to do so, sprinkle it with salt. After removing a leech, employ warm fomentations if continued bleeding is desired. Sometimes the bleeding persists, but this may be arrested by styptic cotton and pressure. In some rare cases the bleeding continues in spite of pressure. This is due to the fact that the tissue contains a considerable quantity of a material secreted from the throat of the leech, which material prevents coagulation of blood. In such a case excise the bite and the area of tissue adjacent to it, and suture the wound. Leeching leaves permanent triangular scars. The Swedish leech, which is preferred to the American, draws from two to four drams of blood. After a leech has been removed, if we desire to use it again, place it in salt water. This causes it to vomit the blood which it has taken up. Leeching has both a constitutional and a local effect. It is at present used comparatively rarely, but it is employed by some practitioners over the spermatic cord in epididymitis, on the temple in ocular inflammation, and over the right iliac region to relieve pain in mild cases of appendicitis.

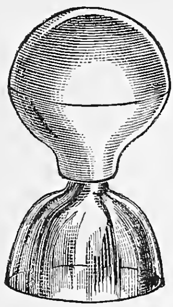


Fig. 50.—Rubber bulb cupper.

Cupping.—Dry cups deviate blood from a deeply placed inflamed area to the surface. Wet cups actually remove blood.

Dry Cups.—Dry cups are applied without first incising the skin. One or more may be applied. A special instrument is sold in the shops for the performance of dry cupping. It consists of a glass bell, with a globular and hollow top of rubber (Fig. 50). The rubber bulb is emptied of air by squeezing, the glass bulb, the edges of which have been greased, is pushed upon the skin, and the compression is relaxed upon the rubber bulb. A partial vacuum is created, and an area of skin and subcutaneous tissue full of blood rises into the glass bell.

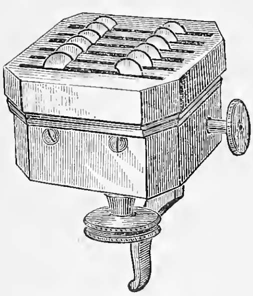


Fig. 51.—Scarificator.

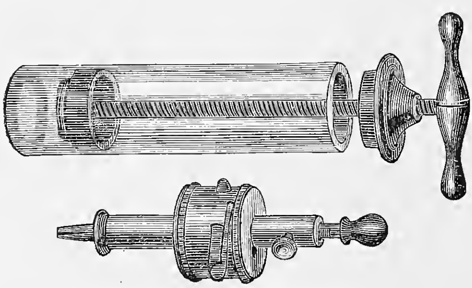


Fig. 52.—Heurteloup's artificial leech.

Cupping can be easily performed by means of a tumbler. The edge of the glass is greased; a bit of blotting-paper wet with alcohol is placed in the bottom of the tumbler and lighted. After a brief period the glass is inverted and placed upon the skin, which has been dampened with warm water. As the air in the glass cools, the tissues rise into the partial vacuum.

Wet Cups.—Wet cups draw blood, and the skin should be cleansed before they are applied. In wet cupping apply a cup for a moment, remove it, incise

or puncture the skin, and replace the cup to draw the requisite amount of blood. Incisions may be made by an ordinary scalpel, a lancet, or a scarificator, a cup being then applied. An excellent scarificator is shown in Fig. 51. In this instrument concealed blades are thrown out by touching a spring. Baron Heurteloup devised an instrument (Fig. 52) in which the incision is made by a scarificator. The blood is drawn out by a pump, the tube being placed upon the cut area and the withdrawal of the piston creating a vacuum. This instrument is known as the "artificial leech." After scarification and the application of the cup, the partial vacuum draws blood into the cup; when the surface ceases to bleed, the cup is removed, and if further bleeding is thought desirable, the clots are wiped away and the cup is again applied, and after its removal warm fomentations are used (Cheyne and Burghard). Wet cupping is of value in pleuritis, pericarditis, and nephritis.

Cutting off the Blood-supply.—Onderdonk, of New York, in 1813 recommended ligation of the main artery of a limb for the cure of inflammation in important structures supplied by the vessel. The procedure was warmly advocated by Campbell, of Georgia, for the treatment of gunshot wounds of joints. This plan of treatment is now not to be considered for a moment; antisepsis furnishes us with a safer and more certain plan. Vanzetti, of Padua, advocates digital pressure to cut off the blood-supply to an inflamed part.

Cold.—Cold is a very powerful and useful agent if used judiciously and applied at the proper time. It is valuable because of its reflex effect upon the vessels of the inflamed area rather than because of direct action upon the cells of a part. It should be used early in the case, before stasis occurs. It is not to be used in the later stages of inflammation, for it will then only aggravate the existing state; in fact, when there is considerable exudation cold does no good.

Cold acts by constricting the vessels of a hyperemic area, thus lessening the amount of blood sent to the part, and preventing the evolution of the process into the stage of stasis and exudation. Further, it prevents the migration of leukocytes, retards cell-proliferation, relieves pain and tension, and lowers temperature. If cold is too intense, if it is kept too long applied, if it is used late in an inflammation, if it is used upon an old or feeble patient, or if it is employed when there is much exudation or a condition of tissue strangulation, it does actual harm. It lessens the nutritive activity of cells, constricts the lymph-spaces and channels, increases existing stasis, and hence lowers the vitality of the tissues. If the parts are constricted, as in strangulated hernia, or if they are compressed by a large exudate, or fed by diseased blood-vessels, cold may cause gangrene. Nancrede, in his "Principles of Surgery," points out that in an inflammation stasis soon arises at the focus of the inflammation, and there is an area of stasis surrounded by a zone of hyperemia. Cold benefits the hyperemic zone but aggravates the stasis. Nancrede cautions us as follows: "Judgment is therefore requisite to decide whether the evil at the focus will not outweigh the good exerted at the periphery." * Nancrede further points out that cold must not be used intermittently; but if employed at all, must be continuously applied. If cold is applied intermittently, there will be a reaction whenever it is removed, and this reaction causes increased

* "Principles of Surgery."

hyperemia. Hence, cold must be "continued in action to prevent reaction." If during the employment of cold the skin becomes purple and congested and the circulation feeble, at once discontinue the use of it, as its continuance will be dangerous.

Cold may be used as wet cold or as dry cold.

Wet Cold.—Wet cold is easily applied, but it is much more depressing than dry cold, is likely to produce discomfort, macerates the skin, and may lead to the formation of excoriations, etc. A part can be subjected to wet cold by the application of evaporating fluids or the use of a siphon. When wet cold is used inspect the part at frequent intervals, and discontinue the treatment if evidences of stasis become positive. Evaporating fluids are extensively employed. If such a fluid is used, never cover the part with a thick dressing. If this should be done, the fluid will not evaporate with sufficient rapidity to produce cold. A piece of thin muslin or flannel should be moistened with the fluid and laid upon the part, and be kept constantly moist by the application from time to time of small quantities of the liquid. Lead-water and laudanum is used extensively, and probably owes its chief value to the fact that it produces cold on evaporation. Lead-water and laudanum is composed of ℥j of laudanum, ℥j of liquor plumbi subacetatis, and 1 pint of water. Liquor plumbi subacetatis dilutus may be used without laudanum. It is thought that the addition of laudanum tends to allay pain. A solution of ammonium chlorid may be used in the strength of ℥j of the drug to 2 quarts of water. If ammonium chlorid is used for more than a short period of time, it is prone to cause the formation of blisters which are irritable and painful. Cheyne and Burghard use the following formula: $\frac{1}{2}$ ounce of ammonium chlorid, 1 ounce of alcohol, and 7 ounces of water. Plain spring-water, iced water, or a mixture of alcohol and water may be used. The *siphon* is occasionally used. If there is a wound, the fluid must be aseptic or antiseptic. In conjunctivitis, cold is applied to the eye by means of linen or muslin soaked in iced water laid upon the closed lids, and frequently changed.

To apply wet cold by means of a siphon, the part is covered with one layer of wet linen or muslin and is laid upon a rubber sheet folded like a trough and emptying into a bucket. A vessel filled with cold water is placed upon a higher level than the bed. A wet lamp-wick is now taken, one end is inserted into the water of the vessel, and the other end is laid upon the part. Capillary action and gravity combine to keep the part moist. A rubber tube may be used instead of a wick. If a tube is employed, tie it in a knot or clamp it so that the fluid is delivered drop by drop (Fig. 54). Ordinary water or iced water can be used. If the water be too warm, it can be reduced to about 45° F. by adding 1 part of alcohol to every 4 parts of water. A mixture of 5 parts of nitrate of potassium, 5 parts of chlorid of ammonium, and 16 parts of water produces great cold.

Dry cold is more manageable and more generally useful than wet cold. It is applied by means of a rubber bag or a bladder filled with ground or finely cracked ice, several folds of flannel being first laid over the part. The flannel collects the moisture from the "sweating" bag and thus prevents maceration of the skin. Further, it saves the tissue from being subjected to too much direct cold and enables us to obtain the beneficial reflex effect. The ice-bag of India-rubber is widely used. We can venture to apply by means of the

ice-bag a greater degree of cold than it is proper to apply by the use of fluids, as dry cold is not so likely to induce gangrene as is moist cold. If there is much tenderness, the weight of an ice-bag causes pain, and it is best to suspend it from a frame, so that it lightly touches the part. The frame is the same as is used to keep the bedclothes from a fractured leg, and can be easily made from barrel hoops. During the time an ice-bag is being used the part must be inspected at brief intervals to see that the circulation is not unduly depressed. The ice-bag is frequently used in joint-inflammation, in intracerebral inflammation, in the earliest stage of appendicitis (see page 863), in epididymitis, and in acute myelitis. If a joint is sprained, the immediate application of an ice-bag is of great service. A part can be encircled with a rubber tube through which iced water is made to flow (Fig. 55). Even when this apparatus is used the part should first be wrapped in flannel. Leiter's tubes, which are tubes of lead made to fit various regions and which

Fig. 53.—Ice-bag (W. E. Ashton).

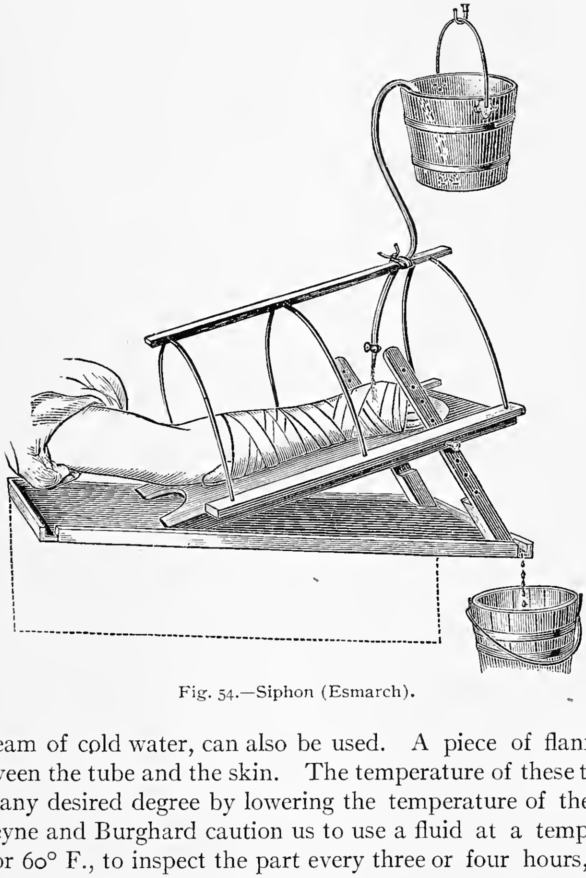


Fig. 54.—Siphon (Esmarch).

carry a stream of cold water, can also be used. A piece of flannel must be placed between the tube and the skin. The temperature of these tubes can be lowered to any desired degree by lowering the temperature of the circulating fluid. Cheyne and Burghard caution us to use a fluid at a temperature not under 50° or 60° F., to inspect the part every three or four hours, and not to employ the tubes longer than twenty-four hours.

Heat is employed by some early in an inflammation. It is rarely beneficial at this stage, except when applied by a hot-air apparatus for the treatment of an injured joint. It is true that a degree of heat which does not actually destroy the tissues will contract the vessels as does cold; but this degree of heat will not be borne by the patient unless but a limited portion of a superficial part is involved.

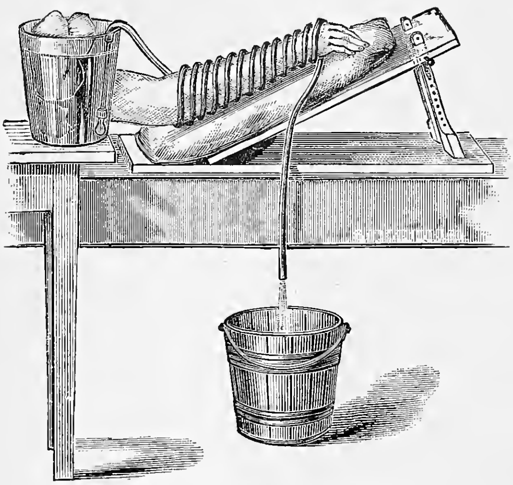


Fig. 55.—The Esmarch cooling coil.

Certain agents are suited to the stage of fully developed inflammation, when there is a great deal of swelling due to effusion and cell-proliferation. The indication in this stage is to abate swelling by promoting absorption. This is accomplished by (1) compression; (2) local use of astringents and sorbefacients; (3) the douche; (4) massage; and (5) heat.

Compression.—Compression is especially useful in fully developed or in chronic inflammation, but it will do good even in the early stages. Compression is of great usefulness; it supports the vessels and causes them to drink up effusion, and it strongly rouses the absorbents. This agent is valuable in most external inflammations with marked swelling and is particularly beneficial in chronic inflammation. In *erysipelas* of an extremity the part should be elevated and the extremity bandaged from the periphery to the body. In *ulcers*, especially those with hard and blue edges, the use of Martin's elastic bandage or of straps of adhesive plaster gives decided relief. In *chronic inflammation of a joint* elastic compression is of great value. In *epididymitis*, after the acute stage, the testicle may be strapped with adhesive plaster. In *lymphadenitis* compression by a weight or by a bandage is very generally employed. In *fractures* compression not only antagonizes spasm, but often combats the swelling and pain of inflammation. Compression must be judicious; it must never be forcible, and it must not be applied to a limb without including the distal portion of the extremity (never, for instance, strongly compress the elbow without including the hand, nor the palm without bandaging the fingers). Injudicious compression causes severe pain and great edema, and may produce gangrene.

Astringents and Sorbefacients.—Astringents may have direct value in inflammation of the skin, but it is not likely that they have any effect on deep-seated inflammation. When used in evaporating lotions in an earlier stage of inflammation the cold does good rather than the drug. Lead-water and laudanum is extensively employed and it is thought to somewhat allay inflammatory pain. The mixture certainly gives comfort in cutaneous erysipelas. It is very doubtful if lead-water is of any service at any stage of a deep-seated inflammation or in any fully developed inflammation. If used after the first stage it must not be applied as an evaporating lotion, because

cold will do harm. Pieces of lint are soaked in the fluid and placed upon the part, and a bandage is applied. The wet lint which has been placed upon the part is covered with oiled silk or a rubber dam before the bandage is applied. If used in the latter manner, the body-heat is retained in the part. If greater heat is required, a hot-water bag can be placed outside of the bandage. Lead-water is not used in treating wounds and hot lead-water should not be applied to a cutaneous inflammation.

Tincture of iodin is astringent, sorbefacient, counterirritant, and antiseptic. It must not be used pure. For application to adults it should be diluted with an equal amount of alcohol, and for children with 3 parts of alcohol. In using iodin, paint it upon the part with a camel's-hair brush and fan it dry, applying one or more coats. The repeated application of iodin to the skin is of great benefit in inflammation of the glands, muscles, tendons, joints, and periosteum. Iodin is apt, after a time, to vesicate, and must not be used in full strength, because it is irritant. It is of special value in chronic inflammation. In deep-seated inflammation it acts as a counterirritant.

Nitrate of silver is a non-irritating astringent of considerable value in inflammation of mucous membranes. It forms a protective coat of coagulated albumin, and is much used in treating the throat, mouth, and genital organs. In urethral inflammation a proteid compound of silver known as protargol may be used.

Ichthyol is a drug of decided efficiency in reducing inflammatory swelling. It is usually employed in ointments, the strength being from 25 to 50 per cent. It is best exhibited with lanolin. When rubbed in over inflamed glands, joints, and lymphatic enlargements, it is of great value. In children a 25 per cent., and in adults a 50 per cent., ointment should be rubbed in thoroughly twice a day. In inflammatory skin-disease, synovitis, thecitis, frost-bite, bubo, chilblain, and in many other conditions, acute or chronic, the use of ichthyol is indicated. The odor of ichthyol is highly disagreeable, and when ordered for a refined person it had better be deodorized. For this purpose Hare uses oil of citronella, ♏xx to ℥j of ointment.

Mercurials.—Blue ointment, pure or diluted to various strengths, is extremely valuable. It is spread upon lint and kept applied over areas of fully developed inflammation. It is especially useful in acutely or chronically inflamed joints, glands, tendons, etc. Blue ointment is strongly irritant, and will soon blister or excoriate a tender skin. It is very beneficial in periostitis, and is employed largely in chronic inflammations.

The Douche.—The douche consists of a stream of water falling upon a part from a height. The water may be poured from a receptacle or may run through a tube, and may be either hot or cold. Alternating hot and cold streams are very popular in inflammations of joints and tendons, especially in chronic inflammation. This mode of application is known as the "Scotch douche." It restores the tone of the blood-vessels and plasma-channels and promotes the absorption of inflammatory exudate. If the part is very tender, the water should be squeezed upon it from sponges. In a sprain of the knee-joint, after a time, when thickening has occurred, pour upon the part daily, from a height, first a pitcherful of very hot water, then a pitcherful of very cold water; then use friction with a hand greased with cosmolin. Hot vaginal douches are generally employed in pelvic inflammations.

Massage.—Massage is a procedure not frequently enough employed. It is very useful in some acute inflammations, though in these it must be gentle. It is of great service in the treatment of sprains of joints and fractures of bones. It is influential for good in chronic inflammations at the period when rest is abandoned. It acts by promoting the movements of tissue-fluids (blood, lymph, and areolar fluid), stimulating the absorbents, strengthening local nervous control, and thus improving nutrition. Passive motion in joints acts as massage.

Heat.—Heat may be used continuously or intermittently, and may be either moist or dry. A considerable degree of heat will act like cold and contract the vessels. The degree necessary to cause vascular contraction would not destroy the tissue, but would produce discomfort, which discomfort would become unbearable during the continuance of the application. Therefore, heat is rarely used in the earliest stage of an acute inflammation. It is hard to state exactly when heat should be substituted for cold. Certainly when retardation and stasis are manifest it is to be preferred. Moderate heat should be used when inflammation is not very superficial. In a cutaneous inflammation heat usually does harm, because it increases the congestion of an inflamed superficial part. In deep-seated inflammations heat to the surface acts as a revulsive or counterirritant. Thus a poultice to the chest may do good in the first stage of pneumonia, and cauterization of the skin near a joint may benefit an acute synovitis. The use of heat for purposes of counterirritation will be discussed under the head of Counterirritants. A moderate degree of heat applied over a fully developed and not too superficial inflamed area dilates the vessels, especially the veins, of the skin and superficial tissues. Thus circulation is re-established in an area filled with stagnant blood or blood which is scarcely moving and the inflamed region is drained, fluid exudate is absorbed, tension is lessened, the lymph-spaces and vessels distend, and lymphatic absorption becomes active. The application of heat increases the ameboid activity of the leukocytes, phagocytes gather in great numbers and surround an area of infection, and those which have taken up bacteria or tissue débris hurry away.* Heat also, in all probability, causes antibodies to escape from the leukocytes and blood-serum. Heat notably lessens the pain of inflammation. It is often used purely to relieve pain.

The *forms of heat* are—(1) fomentations; (2) poultices; (3) water-bath; and (4) dry heat.

Fomentation is the application to the skin of a piece of flannel containing a hot liquid. A basin is warmed and over the top of the basin a towel is placed. A piece of flannel folded in two or three thicknesses is laid upon the towel and boiling water is poured upon it. By twisting the towel the water is squeezed out of the flannel. Great care must be taken to squeeze the water out of the flannel, otherwise the skin may be scalded. The hot flannel is laid upon the skin over the disordered part. A rubber dam larger than the flannel is placed over it, a mass of cotton is laid upon the rubber dam, and a bandage is applied. The fomentation must be changed within an hour unless a hot-water bag has been placed outside the bandage, in which case it need not be changed for two hours or more. The flannel which is dipped into the hot liquid is known as a "stupe." The turpentine stupe is made by wringing out the flannel as above

* Nancrede, in "Principles of Surgery."

and then putting upon it from 10 to 20 drops of turpentine. Instead of fomenting the part, steam may be thrown upon it. Fomentations are used chiefly for their reflex influence over deep congestions or inflammations. The liquid of a fomentation may, if desired, contain corrosive sublimate, carbolic acid, or other agents. A fomentation containing an antiseptic is known as an antiseptic fomentation. An *antiseptic fomentation*, or, as it is often called, an *antiseptic poultice*, is made and applied as follows: Gauze is used instead of flannel, and is laid upon the towel over the basin as previously described. A very warm solution of corrosive sublimate (1 : 1000) is poured upon the gauze, the material is partly wrung out, placed upon the part, covered with a rubber dam, and upon it a hot-water bag is placed. Fomentations are very useful in relieving pain in any stage of an inflammation and act also as counter-irritants. Fomentations are used in preference to ordinary poultices if there is any probability of a surgical operation becoming necessary, because skin to which a poultice has been applied cannot be satisfactorily sterilized. The antiseptic fomentation is of great service in removing sloughs from foul wounds and ulcers. It is the only form of poultice which is admissible when the skin is broken.

Poultice or Cataplasm.—A poultice is a soft mass applied to a part to bring heat and moisture to bear upon it. Poultices can be made of ground flaxseed, of slippery-elm bark, of arrowroot, starch, bread and milk, potatoes, turnips, etc. To make a flaxseed poultice, scald a spoon and a tin basin, put the flaxseed into the dry hot basin, and pour upon it boiling water in sufficient quantity to form a thick paste. The proper consistence is found when the mass would stick if it were thrown against a wall. It is now spread to the thickness of a quarter of an inch upon a piece of warm muslin, a free edge being left all around, the edges of the muslin are turned in, and the flaxseed is covered with a bit of gauze to prevent adhesion to the skin. The poultice should be placed upon the part and be covered outside with oiled silk, a rubber dam, or waxed paper. A mass of cotton is applied outside of the rubber and the poultice is held in place by a bandage or binder. It can be kept very warm for a considerable period by placing upon it a bag filled with hot water. If a hot-water bag is not employed, a poultice should be changed every two hours. Spongiopilin, when moistened with hot water, is a good substitute poultice. Lint soaked with hot water and covered with some impermeable material does very well. The fermented poultice, which was once popular for gangrenous ulcers, was made by sprinkling yeast upon an ordinary cataplasm. The charcoal poultice is made by stirring charcoal into the usual poultice-mass. A poultice containing opium is known as a "sedative" poultice. About gr. ij of opium to the ounce of poultice-mass may relieve pain. Flaxseed is a vegetable material, adheres to the skin, enters the mouths of glands and follicles, undergoes decay, and can be removed only with great difficulty. The preparation of an antiseptic *poultice* or fomentation is described above. Poultices must not be kept on the part too long, as they will cause vesication, especially in adynamic conditions. If a poultice is causing vesication, remove it and do not replace it, or replace it after sprinkling the part and the poultice with powdered oxid of zinc. If suppuration exists or is seriously threatened, do not waste time by using poultices, but incise at once. Incision may prevent suppuration by relieving tension, affording drainage, and permitting the

local use of antiseptics. If pus exists, it cannot be evacuated too soon. To use poultices and delay incision is often productive of irreparable harm. After incision of a purulent focus it is common practice to apply an antiseptic fomentation in order to draw quantities of leukocytes to the part and thus limit the spread of infection and stimulate granulation.

Hot-water Bath.—The continuous hot bath is now rarely employed except in burns and cases of phagedena, when it often proves curative. In these cases an antiseptic agent may be dissolved in the water. Continuous immersion in a warm bath is regarded favorably by some surgeons for the treatment of sloughing wounds and large purulent areas. The immersion of a part from time to time in water as hot as can be tolerated is useful in fully developed and in chronic inflammation. Such immersion benefits an inflamed joint, lessening the pain, swelling, and stiffness.

Dry heat is applied by a metallic object dipped in hot water and laid upon the part; by Leiter's tubes, through which hot water flows; by the hot-water bag or by the hot-air apparatus. Some surgeons use the hot-water bag in cases of mild appendicitis, in order to favor the formation of adhesions. The hot-water bag is often soothing and beneficial when laid upon an inflamed joint, or on the perineum or the hypogastric region in cystitis. A bag of hot sand, a hot brick, or a bottle or can of hot water may be used instead of the bag. The hot-air apparatus is of very great service in the treatment of inflamed joints (*vide* dry hot-air apparatus).

Treatment when Suppuration is Threatened.—When suppuration is threatened, ordinary hot fomentations or antiseptic fomentations must be used, and the part must be kept at rest. As previously explained, the flaxseed poultice is inadmissible. When suppuration is threatened, the use of heat causes the collection of multitudes of leukocytes, which tend to limit the area of infection and destroy bacteria. Even when suppuration is not prevented, heat aids in the rapid breaking down of the diseased tissue at the focus of the inflammation and causes hordes of leukocytes to gather and encompass the suppurating tissue, and these leukocytes prevent the spread of the infection.

In most cases, when suppuration is obviously inevitable or seriously threatened, a *free incision* will be of greatest benefit.

Irritants and Counterirritants in Inflammation.—*Irritants* attract an increased supply of blood to the part whereon they are applied, and are used for their local effects. *Counterirritants* are used to affect by reflex influence some distant part. In chronic inflammation irritants may do good by promoting the blood-supply, thus favoring the removal of exudates (liniment for rheumatism and synovitis, and nitrate of silver for ulcers). Counterirritants are powerful pain-relievers when used over an inflamed structure; they bring blood to the surface and are thought by many writers to cause anemia of internal parts, the site and area of anemia depending on the site, the area, and the duration of the surface irritation. Some recent studies seem to indicate that counterirritation produces hyperemia of the superficial part, compensatory anemia of surrounding regions, and anemic edema of the subcutaneous tissue and muscles (W. Wecksberg, "Zeit. f. klin. Med.," Bd. xxxvii, H. 3 u. 4). Nancrede dissents from the statement that counterirritants cause anemia of internal parts; and he maintains that they irritate deeper parts

and cause more external blood to be taken to them. He claims that a blister applied to the chest produces a hyperemic area in the pleura, and refers to Furneaux Jordan's opinion that direct irritation to the surface over a joint adds to synovial hyperemia, and that consequently in joint-inflammation counterirritants should be applied above and below a joint, but not directly over it. As a matter of fact, we know clinically that powerful counterirritation directly over an inflamed superficial joint is occasionally followed by an aggravation of the trouble, and that in pericarditis blistering directly over the pericardium may, as pointed out by Brunton, make the condition worse. Counterirritants not only relieve pain in the earlier stages of inflammation, but they also promote absorption of exudate in the later stages, and are particularly valuable in chronic inflammations. Great benefit is obtained by blistering old thickened ulcers, and by painting the chest with iodin to relieve pleuritic effusion. Frictions, besides their pressure effects, act as counterirritants. Frictions may relieve skin pain, and are associated with the application of stimulating liniments in the treatment of stiff joints. A mustard plaster is a valuable counterirritant in an acute deeply seated inflammation. Tincture of iodin is extensively used in chronic inflammation.

There is no more efficient method of relieving pleural effusion than by the application of a succession of blisters. Blisters are also used in the treatment of inflamed joints, pericarditis, pneumonic consolidation of the lung, acute and chronic rheumatism, etc.; and are applied back of the ears or at the nape of the neck in congestive coma or meningitis. A blister can be produced in a few minutes by soaking a bit of lint in chloroform, and after applying it to the surface, covering it with oiled silk or with a watch-glass. Equal parts of lard and ammonia will blister in five minutes. It is easier to blister with cantharidal collodion or blistering paper. Before applying a blister, shave the part if it be hairy; then grease the plaster with olive oil and apply it. Blistering plaster is left in place six hours in the case of an adult, but only two hours in the case of an old person or a child; the plaster is then removed, and if a blister has not formed, the part must be poulticed for a few hours. When a blister is obtained, open it with a needle which has been dipped in boiling water. If the surgeon wishes the blister to heal, it should be covered with a piece of lint smeared with cosmolin or with zinc ointment. If it is to be kept open for a time, cut away the stratum corneum and dress with cosmolin, each ounce of which contains six drops of nitric acid.

Pustulation can be effected with tartar-emetic ointment or with Vienna paste. Tartar-emetic ointment was formerly used on the scalp in meningitis. Vienna paste consists of 5 parts of caustic potash and 6 parts of lime made into a paste with alcohol. It is applied for five minutes, and is then washed off with vinegar.

The hot iron is the most powerful of counterirritants. It is chiefly used in chronic inflammation of joints, bone, and the spinal cord. The application is, of course, very painful, and it is best to give an anesthetic before using the cautery. A flat cautery iron may be used, or the round iron. The latter is known as the button or Corrigan's cautery. The iron is used at a white heat. One area or several may be seared. The cautery is drawn lightly two or three times over each spot we wish to burn. The object is to destroy only the superficial layers of the skin. After the cauterization is completed, lint wet

with iced water is applied for several hours to allay pain, and then hot antiseptic fomentations are used until the slough separates.

If we wish to prevent healing after separation of the slough, dress the sore with cosmolin, each ounce of which contains 6 drops of nitric acid. It is not wise to cauterize deeply directly over a superficial joint.

Constitutional Treatment of Inflammation.—Certain remedies are used in inflammation for their general or constitutional effects; these remedies are—(1) general bleeding; (2) arterial sedatives; (3) cathartics; (4) diaphoretics; (5) diuretics; (6) anodynes; (7) antipyretics; (8) emetics; (9) mercury and iodids; (10) stimulants; and (11) tonics.

General Bleeding, Venesection, or Phlebotomy.—Venesection is suited to the early stages of an acute inflammation in a young and robust subject. The indication for its employment is increased arterial tension, as shown by a strong, full, rapid, and incompressible pulse in a vigorous young patient. General blood-letting diminishes blood-pressure and increases the speed of the blood-current, thus amends stasis, absorbs exudate, and washes adherent corpuscles from the vessel-wall; furthermore, it reduces the whole amount of body blood and thus forces a greater rapidity of circulation, decreases the amount of fibrin and albumin, lowers the temperature, arrests cell-proliferation, and stops effusion.

This procedure was in former days so highly esteemed that it settled into a routine formula to be applied to every condition from yellow fever to dislocation. The terrible mortality of the cholera epidemics from 1830 to 1835 led practitioners to question the belief that bleeding was a general panacea, and from this doubt there was born in the next generation violent opposition to blood-letting in any disease. Like most reactions, opposition has gone too far, the pendulum of condemnation has swung beyond the line of truth and sense, and thus is universally neglected or broadly condemned a powerful and valuable resource. Many physicians of long experience have never seen a person bled; its performance is not demonstrated in most schools, and but few patients and families will permit it to be done. But when properly used it is occasionally beneficial. It is applicable, however, only to the young, strong, and robust, and not to the old, weak, or feeble. It is used for violent acute inflammations of important organs or tissues, and not for low inflammations or for slight affections of unimportant parts. It is used in the early, but not in the late, stages of an inflammation. It is used when the pulse is frequent, full, hard, and incompressible, but not when it is slow, small, soft, compressible, and irregular. It is used when the face is flushed, but not when it is pallid. It is not used in fat persons, drunkards, very nervous people, or the sufferers from adynamic, septic, or epidemic diseases. It is of value in some few cases of congestion of the lungs, pneumonitis, pleuritis, meningitis, prostatitis, cystitis, and other acute inflammatory conditions. It is particularly valuable when uremia exists or when there is distention of the right side of the heart. The method of bleeding is described on page 398.

After bleeding, the patient should be put on arterial sedatives, diuretics, diaphoretics, anodynes, and, if necessary, purgatives. A favorite mixture of Prof. S. D. Gross was the antimonial and saline, gr. xl of Epsom salt, gr. $\frac{1}{10}$ of tartar emetic, 2 drops of tincture of aconite, and ʒj of sweet spirits of niter, in enough ginger syrup and water to make ℥ss; given every four hours.

Arterial Sedatives.—Drugs of this character are of great use before stasis is pronounced; but if used after stasis is established they will increase it. If stasis exists it may be relieved by blood-letting, local or general, and then arterial sedatives can be given. Either local bleeding or venesection abolishes stasis and lowers tension, and arterial sedatives maintain the effect and hold the ground which is gained. The arterial sedatives employed are aconite, veratrum viride, gelsemium, and tartar emetic. These sedatives lessen the force and the frequency of the heart-beats, and thus slow and soften the pulse, and are suited to a robust person with an acute inflammation, but are not suited to a weak individual in an adynamic state.

Aconite is given in small doses, never in large amounts. One drop of the tincture in a little water is given every half hour until its effect is manifest on the pulse, when it may be given every two or three hours. Large doses of aconite produce pronounced depression, and are dangerous. Aconite lowers the temperature, slows the pulse, and produces diaphoresis.

Veratrum viride is a powerful agent to slow the pulse and to lower blood-pressure; it produces moisture of the skin, and often nausea. It is given in 1-drop doses of the tincture every half hour until its physiological effects are manifested, when the period between doses is extended to two or three hours. Ten drops of laudanum given a quarter of an hour before each dose of veratrum viride will prevent nausea.

Gelsemium is an arterial sedative highly approved by Bartholow. It is given in doses of 5 to 10 drops of the tincture every three or four hours.

Tartar emetic lowers arterial tension and lessens the pulse-rate. This drug is not generally employed; if it is used with the greatest care it is no better than some other agents, and if it is not so used it will cause dangerous depression. The dose is from gr. $\frac{1}{20}$ to gr. $\frac{1}{10}$ in water every three hours until the physiological effects are manifest.

Cathartics.—Purgation is of great value in inflammation. By it putrid material is removed from the intestine, fluid containing poisonous elements is drawn from the blood, and the liability to infection of the tissues is lessened. The administration of purgatives is, of course, not to be a routine procedure in inflammatory states. The bowels may be acting so freely that no cathartic is required. Treatment in an inflammation should be inaugurated, if constipation exists, by giving a cathartic. The tongue affords important indications as to the necessity for purgation. Castor oil can be given in capsules, or the juice of half a lemon is squeezed into a tumbler, 1 ounce of oil poured in, and the rest of the lemon is squeezed on top, thus making a not unpalatable mixture. Aloïn, podophyllum, the salines, and calomel in 5- or 10-grain doses, followed by a saline, have their advocates. In peritonitis the salines are of unquestionable value, a teaspoonful of Epsom salt and a teaspoonful of Rochelle salt being given hourly until a movement occurs. In the course of inflammation, from time to time, if there be constipation, a coated tongue, and foulness of the breath, there should be ordered gr. j of calomel with gr. xxiv of bicarbonate of sodium, made into twelve powders, one being given every hour; if the bowels are not moved by the time the powders are all taken, a saline should be given. If a violent purgative effect is desired, as in meningitis, croton oil or elaterium may be ordered. If constipation is persistent, give fluid extract of cascara sagrada daily (20 to 40

drops), or a pill at night containing gr. $\frac{1}{4}$ of extract of belladonna, gr. $\frac{1}{4}$ of extract of nux vomica, gr. $\frac{1}{10}$ of aloïn, gr. $\frac{1}{4}$ of extract of physostigma, and gtt. $\frac{1}{2}$ of oil of cajuput. Enemas or clysters may be used in some cases. A very useful enema is composed of f℥j of oil of turpentine, f℥iss of olive oil, f℥ss of mucilage of acacia, in f℥x of water. Soapsuds and vinegar in equal parts make a serviceable clyster. A combination of oil of turpentine, castor oil, the yolk of an egg, and water can be used. Asafetida, gr. xxx to the yolk of one egg, makes a good enema to amend flatulence.

Diaphoretics.—These agents are very useful. A profuse sweat removes much toxic material from the blood and in the beginning of an acute inflammation, such as tonsillitis, may abort the disease. Dover's powder is commonly used, but pilocarpin is preferred by some. Camphor in doses of from 5 to 10 grains is diaphoretic, and so are antimony and ipecac. Acetate and citrate of ammonium, opium, alcohol, hot drinks, heat to the surface (baths, hot bricks, hot-water bags), serpentaria, and guaiac are diaphoretic agents.

Diuretics.—Diuretics are useful in fevers when the urine is scanty and high-colored, and are valuable aids in removing serous effusions and other exudates. Among the diuretics may be mentioned calomel in repeated large doses, cocain, alcohol, digitalis, the nitrites, squill, turpentine, copaiba, and cantharides. The liquor potassæ and the acetate of potassium are the best agents to increase the solids in the urine. The liquor potassii citratis in doses of f℥j to f℥iv is efficient. Large draughts of water wash out the kidneys. If the heart is weak, citrate of caffein is a good stimulant diuretic, and hot coffee is very serviceable in promoting the secretion of urine. The injection of hot salt solution into the rectum and under the skin favors diuresis, and the intravenous infusion of salt solution is a very powerful diuretic. The application of heat to the loins promotes the secretion of urine. Sodio-theobromin salicylate (diuretin) is an uncertain but often valuable diuretic, in doses of gr. x every two or three hours.

Anodynes and Hypnotics.—Drugs may be required to allay pain or procure sleep. Dover's powder, besides being diaphoretic, is anodyne. Opium acts well after bleeding or purgation. If it causes nausea, it should be preceded one hour by the administration of gr. xxx of bromid of potassium. Opium is used by the mouth, by the rectum, or hypodermatically. It is used when there is pain, but its use is not to be long persisted in if it can be avoided. It is given in doses measured purely by the necessities of the case. If opium disagrees, try the combination of morphin with atropin. After an operation antipyrin or phenacetin will often quiet pain and secure sleep. When a person feels "so tired he can't sleep," alcohol in the form of whiskey or brandy must be given. Sleeplessness not due to pain is met by chloral, trional, the bromids, or sulphonal. Chloral is dangerous in conditions of weak heart or exhaustion. Bromids must be given in large doses to be efficient. Sulphonal must be given about four or five hours before sleep is expected, in doses of from gr. x to gr. xx in hot milk or hot mint-water. Trional is safe and very satisfactory. It is given in doses of gr. xv to gr. xxv in hot water.

Antipyretics.—Arterial sedatives, diaphoretics, and purgatives lower temperature, and have previously been alluded to (page 103). There are two great classes of febrifuges—those which lessen heat-production and those which increase heat-elimination. In the first group we find quinin, salicylic

acid and the salicylates, kairin, alcohol, antimony, aconite, digitalis, cupping, and bleeding. In the second group we find alcohol, nitrous ether, antipyrin, acetanilid, phenacetin, opium, ipecac, cold to the surface, and cold drinks. In surgical inflammations it is rarely necessary to employ heroic means to lower temperature. The use of such an agent as antipyrin is contraindicated in the weak and adynamic, and it is never to be thought of as a means of lowering temperature unless the latter goes above 103° F. Quinin, in doses of gr. xx to gr. xxx given at 4 P. M., may prevent an evening rise; salol or salicin can be given during the day. Inunctions of 30 minims of guaiacol lower the temperature in tuberculous conditions and in septic fevers. These inunctions are made upon the abdomen, and often produce surprising results. Dujardin-Beaumetz maintained that fever is a condition in which the animal organism is endeavoring to oxidize and render inert certain poisonous material, and that antipyretic drugs lessen oxidation and actually make the patient worse. This view is in accordance with the experience of a number of surgeons. It is a suggestive fact that bacteria are said to multiply more rapidly when kept at about the normal body-temperature than when kept at fever heat (102° F., or more). The mere discomfort of fever may be much mitigated by antipyretic drugs, but the fever process is not benefited by them.

Emetics.—Emetics may do good when the patient suffers from a parched, coated tongue, a dry and hot skin, nausea, and gastric oppression, but it is very rarely in these days that we employ them. There can be used ʒj of alum in molasses, gr. xx of sulphate of zinc, or a tablespoonful of mustard and a teaspoonful of salt given in warm water and followed by large draughts of warm water. Ipecac in a dose of gr. xx can be employed. The emetic dose of tartar emetic is gr. ij, but it is too depressant a drug to trifle with. The sulphuret of antimony in doses of from 1 to 5 grains is safe. Apomorphin hypodermatically, in a dose of from gr. $\frac{1}{16}$ to gr. $\frac{1}{8}$, will act in five minutes. Emetics are valuable in inflammatory conditions of the air-passages, but their use is contraindicated in diseases of the heart, brain, and bowels, in hernia, in dislocations, in fractures, and in aneurysms.

Mercury and the Iodids.—Mercury is an alterative—that is, an agent which favorably affects body nutrition without causing any recognizable change in the fluids or the solids of the body. Mercury lessens blood plasticity, hinders the exudation of liquor sanguinis—thus furnishing less food to the cells in the perivascular tissues—and retards cell-proliferation. Further, by a stimulant action on the absorbents it promotes the breaking up of an existing inflammatory exudation, and hence limits damage from excess of new formation. The time at which mercury is best given is when violent symptoms have abated, the guides being a reduced temperature and a moist skin. Mercury is often given in conjunction with the local use of sorbefacients (ichthyol, or mercurial ointment). When possible, the administration of mercury is associated with compression of the inflamed part. It is sometimes given until the gums are slightly touched, but it is not given to the point of salivation. When the breath becomes offensive and the gums tender on snapping the teeth, or when griping and diarrhea begin, the dose should be reduced, or the drug should be stopped (see Ptyalism). In iritis mercury is used to get rid of the plastic effusion which is causing pupillary fixation and opacity. In keratitis the gums should be touched *slightly*. In orchitis, after

the subsidence of the acute symptoms, mercury should be employed. In pericarditis, meningitis, and in many chronic and lingering, and in all syphilitic inflammations, this drug can be used.

Some persons will be salivated with very minute doses of mercury, either because of idiosyncrasy or previous saturation. Others can take enormous doses without any appreciable constitutional effect. The action of mercurials can be favored by a combination with ipecac or with tartar emetic.

In giving mercury, if a prompt effect is desired, give gr. iij of calomel every three hours until a metallic taste is noted in the mouth. If the case is not so urgent, gray powder is a good combination. Children are given calomel and sugar or mercury and chalk. If it is desired to give the drug for some time, corrosive sublimate is a suitable form, and small doses will actually increase the number of red blood-corpuscles. Corrosive sublimate is to be given alone or combined only with iodid of potassium. The green iodid of mercury is a drug suitable for prolonged administration. In the prolonged use of mercury it will often be necessary to give at the same time a little opium to prevent diarrhea and griping. A rapid effect can be obtained by rubbing daily with a gloved hand ʒj of the oleate of mercury or ʒss of the ointment into the groins, the axillæ, or the inside of the thighs. Suppositories of mercurial ointment induce rapid ptyalism. Hypodermatic injections of corrosive sublimate or gray oil may be used, and must be thrown deeply into the muscles of the buttock or back. Old people, those who are exhausted, anemic, and broken down, and the tuberculous bear mercury badly. If it be given to them at all, it must only be in small amounts and for a brief time.

Alkaline iodids are useful in removing the products of inflammation; they can be given for a long time, and admirably supplement mercurials. Iodid of potassium can be prescribed in combination with corrosive sublimate as follows:

℞. Hydrarg. chlor. corros., ... gr. ij;
Potass. iodidi, ... ʒv et ℈j;
Syr. sarsaparillæ comp., ... q. s. ad f℥viij.—M.
Sig.—fʒij, in water, after meals.

Iodid of potassium, well diluted, is given on a full stomach; it is never given concentrated or before meals. A convenient mode of administration is to procure a concentrated solution of the iodid of potassium, remembering that every drop equals about gr. j of the drug, and give as many drops as may be desired in half a glass of water after meals. If the medicine disagrees, add to each dose, after it is put in water, ʒj of the aromatic spirit of ammonia. Extract of licorice is a good vehicle for the iodid. If the mixture in water disagrees, the drug should be given in milk. Capsules are satisfactory, but a drink of water should be taken just before and again just after taking a capsule, to protect the stomach from the concentrated drug. Iodid of sodium may agree when iodid of potassium does not. When the iodids disagree they produce iodism. The first indications of iodism are a bad taste in the mouth, running of the eyes and nose, and sneezing, followed by a feeling of exhaustion, absolute loss of appetite, nausea, tremor, and skin eruptions (acne, hemorrhages, blebs, hydroa, etc.). If iodism occurs, stop the drug and give the patient Fowler's solution in increasing doses, laxatives, diuretic waters, and also nutritious food, and stimulants if depression is great. Sometimes belladonna does good in obstinate cutaneous disorders induced by the iodids.

Remedies Directed Against Special Morbid States.—If inflammation is associated with rheumatism, gout, scurvy, syphilis, tuberculosis, or any other constitutional disease or predisposition, appropriate treatment should be instituted to control the disease or combat the predisposition, and at the same time the area of inflammation should be locally treated. Syphilis is treated by the internal use of mercury; in some cases the iodids are also given; scurvy, by vegetable juices and potash salts; rheumatism, by the alkalies or salicylates; gout, by colchicum or piperazin; tuberculosis, by the fats, tonics, and open-air life.

Stimulants.—The chief stimulants used are hot black coffee by the stomach or bowel; hot normal salt solution by the bowel, beneath the skin, or in a vein, alcohol by the mouth or rectum; and strychnin or atropin hypodermatically. The use of *alcoholic stimulants* is called for by conditions rather than by diseases, being indicated by the state of the patient rather than by the name of the malady. For a brief acute inflammation in a robust young person alcohol is not needed; but all who are weak or exhausted, be they young or old, all who are aged, those who are accustomed to alcoholic beverages, those who have high temperatures or failure of circulation, and those who labor under septic inflammations or adynamic processes require alcohol, and it should be given with a free hand. In an acute malady, a feeble, compressible, rapid, or irregular pulse, and great weakness of the first sound of the heart are indications that alcohol is required. Low, muttering delirium is a strong indication for stimulation. There is no *dose* of alcohol for these states; it is given for its effect. Two ounces of brandy or whiskey may be needed in a day, or perhaps 20 ounces. If the breath of the patient smells strongly of the alcohol, he is getting too much. If delirium increases after each dose, alcohol is doing harm. Alcohol is contraindicated in acute meningitis. In acute illness use whiskey, brandy, champagne, or alcohol and water. During convalescence there may be used a little port, claret, or sherry wine, or malt liquor. These agents will promote appetite, digestion, and sleep.

Strychnin is a very valuable stimulant. It can be given in doses of gr. $\frac{1}{60}$ to gr. $\frac{1}{20}$ three times a day, but after a few days seems to lose its effect.

Atropin is one of the best remedies for exhaustion of the vasomotor system. The dose is gr. $\frac{1}{100}$ hypodermatically.

Tonics.—The use of tonics is indicated during convalescence from acute and throughout the course of chronic inflammations. There may be used iron, quinin, and strychnin in the form of elixir; iron alone, as in the tincture of the chlorid; quinin in tonic doses (gr. vj to gr. viij daily); or Fowler's solution of arsenic. An excellent pill consists of—

℞.	Acid. arsenos.,	gr. j;
	Strychnini,	gr. ss;
	Quinini,	gr. xlviij;
	Ferri redact.,	gr. vj.—M.

Ft. in pil. No. xxiv.
Sig.—One after each meal.

Bitter tonics before meals improve the appetite. One of the best of tonics is tincture of nux vomica in gradually increasing doses.

Antiphlogistic Regimen.—This term comprises the necessary directions relating to diet, ventilation, cleanliness, etc.

Diet.—When, in the early stages of an acute inflammation, the patient

cannot eat, there must be administered a cathartic before food is given. Nausea is combated with calomel and soda, drop-doses of a 6 per cent. solution of cocain, iced champagne, iced brandy, chloroform-water, hot water, cracked ice, or the application of counterirritation to the epigastric region. When the process is depressive from the start, and in any case after the earliest stage, feeding is of vital moment. The great tissue-waste calls for large quantities of nutritive material, but the impaired digestion demands that the food shall be easily assimilable; hence it is taken in liquid form, small quantities being frequently given. Milk contains all the elements required by the body, and is the food of foods. If it disagrees, it should be boiled and mixed with lime-water, or to each dose an equal amount of Vichy or soda-water may be added. Peptonized milk is a valuable agent. One part of milk, 2 parts of cream, and 2 parts of lime-water make a nutritious and digestible mixture. Milk punch is largely used. Whey may be used when plain milk cannot be taken. Eggs are highly nutritious, but are apt to disturb the stomach; they may be given as egg-nog, or simply soft-boiled, or the yolk can be beaten up in a cup of tea. When considerable nausea exists, the yolk of an egg may be added to ℥j of lemon-juice and ʒij of sugar, the glass being filled with carbonated water. Beef tea is certainly a stimulant, but its food powers are questionable. It is prepared by cutting up one pound of lean beef, adding to it a quart of water, and then simmering, but not boiling, down to a pint, finally filtering and skimming the liquid. The dose is a wineglassful seasoned to taste. Meat-juice, obtained by squeezing partly cooked meat with a lemon squeezer, is extremely nutritious. Liquid-beef peptonoids are both agreeable and nutritious; they are given in doses of ℥ss to ℥j. Clam-juice is palatable and digestible. When nothing else will stay on the stomach koumiss will often be retained. This fermented milk is nutritious, stimulant, and very useful. Coffee is a valuable stimulant in febrile conditions. If the stomach retains no food, the patient must be fed entirely by the rectum. If the stomach rejects most of the food swallowed, mouth feeding must be supplemented by nutritive rectal enemata. When the sufferer feels able to eat a little, any good soup, strained and skimmed, should be ordered. As the patient gets better he may be fed on sweetbreads, chops, oysters, etc., until he gradually reaches ordinary diet.

The *temperature* should be taken at regular intervals, and the condition of the gastro-intestinal tract should be observed. The *urine* must be examined at intervals, and the daily amount passed must be known. If insufficient urine is being passed, increase the amount of fluid, particularly of water, given by the mouth. If the urine is scanty and the patient is nauseated by drinking water, give enemata of hot saline fluid or employ hypodermoclysis. The *pulse* and *heart* must be frequently observed, and cardiac weakness must be combated by suitable stimulants.

Ventilation and Cleanliness.—The ventilation of the apartment is of the greatest importance. Every day the windows should be opened widely for a time, the patient, of course, being protected. When the windows are open the air of a room can be quickly changed by swinging the door to and fro. A constant access of fresh air must be secured, and the temperature kept as near as possible to 68° F. The sick man must be cleaned and be sponged off with alcohol and water every day if high fever exists. It is important that the bed-

clothing be clean and that the sheet be unwrinkled, as otherwise bed-sores may form.

Treatment of Chronic Inflammation.—The subject of chronic inflammation has been referred to previously. The local treatment comprises rest, relaxation, elevation, counterirritation, massage, passive movements, the douche, the application of sorbefacients, the use of compression, incision, and perhaps, certain special methods as the induction of passive hyperemia by Bier's method (page 228) or baking the part in a hot-air oven. The patient must be placed under proper hygienic and climatic conditions; the diet must be judiciously regulated; drugs are given symptomatically or to combat some constitutional tendency or disease (see articles upon special regions and diseases).

IV. REPAIR.

When a tissue is damaged, it reacts to the injury and Nature attempts to effect repair. It is held by many that inflammation is a destructive process and repair is a constructive process; that repair is constantly effected in an aseptic wound without many of the evidences of inflammation; that repair does not proceed from inflammation, but is retarded or prevented if inflammation occurs. As before stated, we agree with Adami, that inflammation is reaction to injury and the effort of Nature to repair the injury. As Adami points out, the attempt to repair may fail, the reaction to injury being excessive or not powerful enough; but even should the attempt fail, the conservative intention exists. "What is the development of cicatricial tissue but an attempt at repair? What other meaning can be ascribed to the increased bactericidal power of the inflammatory exudate as compared with that of ordinary lymph and blood-serum? Why do leukocytes accumulate in a region of injury? Why do some of them incorporate bacteria and irritant particles, and others bring about the destruction of these without necessarily ingesting them? All these are means whereby irritants are antagonized or removed, and reparation and return to the normal sought after." *

Repair is favored by good general health, asepsis of the wound, coaptation of wound edges, and rest. It is retarded or prevented by infection, gaping of the wound, frequent or forcible motion, and impairment of the general health. *Albuminuria* and *diabetes* particularly obstruct repair. R. T. Morris points out that sugar in the blood is hygroscopic, removes water from the tissues, and thus obstructs repair; and also that the wound fluids contain sugar and are good culture-media ("Med. News," June 29, 1901).

Healing by First Intention.—A wound may heal by "first intention." This mode of healing, which is known as "primary union," occurs without suppuration, and is observed in the healing of an aseptic wound. If infection occurs, primary union will not take place. The phrase "by first intention" comes down to us from the past. It was properly thought that Nature intends to repair a wound, and first intention signifies the first or most desirable way to be wished for. In a small aseptic incision, in which no considerable vessels are cut, repair will take place very rapidly after the edges have been approximated and the wound dressed. In fact, the wound edges may be firmly held together in twenty-four hours. In such a wound a small amount of blood flows from the capillaries between the edges of the wound, and this blood clots. A trivial amount of exudation and some few migrated corpuscles pass into the clot and into the tissues. The fixed connective-tissue cells and the endothelial cells of the vessels multiply, and form epithelioid cells, known as fibroblasts. The fibroblasts eat up many of the leukocytes and multiply, so that the new cells from one side of the wound finally interlace with the new cells from the other side. Nearby capillaries become irregular in outline; at certain points bulging occurs, and at these points new capillaries develop, extend into the mass of fibroblasts, and join new capillaries of the opposite side. The reparative material is now said to be organized; it has

* Adami, in Allbutt's "System of Medicine."

become granulation tissue. The fibroblasts become spindle-shaped and develop into interlacing fibers (Fig. 56). The tissue is now fibrous tissue; it contracts strongly, and finally most of the capillaries are obliterated by pressure. In such a slight wound the reaction to injury is chiefly noted in the cells of the part, and the vessels and leukocytes play but a small part in repair. The exudation is so scanty that there is practically no swelling unless some arises from venous obstruction. The vessels are so slightly affected that there is no redness. The final step in healing is contraction of the fibrous tissue and the covering of the surface with epithelium, which springs from the epithelial cells upon the edges. This final process is called "cicatrization," and consists in the formation from fibroblasts of new fibrous tissue and the contraction of the new tissue. The "immediate union" of some writers never occurs. This term means the union of microscopical parts to their counterparts without any effort at repair. A first union is effected always by clotted blood and coagulated exudate, next by proliferating cells, and finally by fibrous tissue. A wound healing by first intention exhibits no evidence of inflammation. There is some slight tenderness, but no actual pain. A certain amount of swelling arises because of exudation of fluid from the blood, and the coagulation of this fluid makes the wound edges hard. Venous obstruction leads in some cases to a considerable fluid swelling. A wound may heal by first intention even if some bacteria are present, if the part has a good blood-supply and the patient is in good health. Active leukocytes and germicidal blood-serum may prevent infection. In a more extensive incised wound many vessels are cut. After oozing ceases the vessels are closed by clots continuous with the clot between the sides of the wound. An exudation of plasma from the blood-vessels and of lymph from the lymph-spaces takes place. Leukocytes in great numbers invade the wound edges and the exudate, and the exudate clots. Thus, an infection may be surrounded and limited. This mass of blood-clot, plasma-clot, and leukocytes used to be known as "coagulable lymph." The leukocytes actively eat up the clot, and by the end of the third day occupy the space formerly occupied by the clot. The fixed connective-tissue cells and endothelial cells multiply and grow into the mass of leukocytes, eating up many of the leukocytes, and finally join the fibroblasts of the other side of the wound. Some leukocytes enter into the lymph-spaces. New capillaries form from the capillaries at the wound margins. By the end of the first week the fibroblasts begin to assume various outlines, sending out poles or branches or becoming spindle-shaped. These spindle-shaped cells become fibers, and the fibers of the new tissue interlace and strongly contract. Thus the edges are pulled firmly together. Finally new epithelium derived from epithelium at the edges forms and grows over the wound (Figs. 57-59), and exhibits the stages of repair in healing by first intention. In order to obtain primary union the surgeon must cleanse the wound and must be thoroughly aseptic; bleeding must be carefully arrested; the parts are accurately coaptated by sutures; aseptic or antiseptic dressings are applied, and special care is taken to secure *rest*. In a large wound special methods to secure drainage are required. In

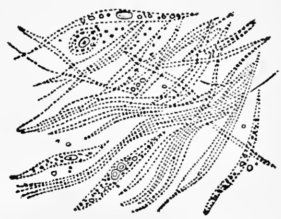


Fig. 56.—Cells developing into fibers (Bennett).

a small wound drainage is obtained between the stitches. The use of irritant germicides in a wound greatly increases the amount of discharge and renders drainage necessary in even a comparatively small wound for the first twenty-

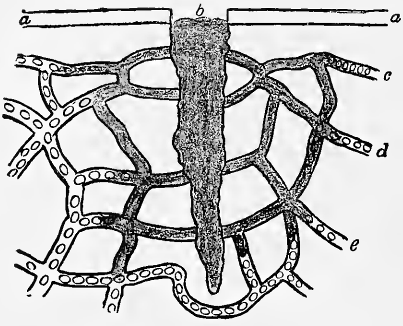


Fig. 57.

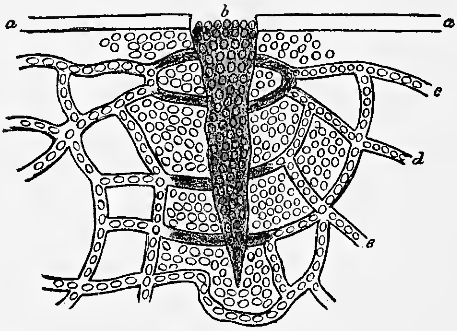


Fig. 58.

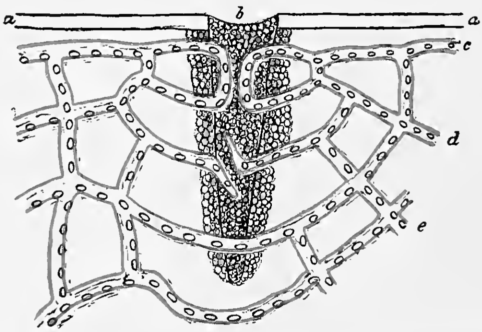


Fig. 59.

Figs. 57-59.—Healing by first intention (after Pick): *a*, Skin; *b*, fibroblasts; *c*, *d*, *e*, capillaries. Fig. 57, Clot in the vessels continuous with clot between the edges of the wound. Fig. 58, Migration of leukocytes into the perivascular tissues and into the clot between the edges of the wound. Fig. 59, Formation of new capillaries.

four hours. During the first twenty-four hours after a large wound begins to heal by first intention the discharge of bloody serum is most plentiful, but after this period it becomes very scanty and soon ceases entirely, and can be much

diminished in quantity in the first day by the application of pressure. Warren says that after a hip-joint amputation over a pint of bloody serum flows out during the first twenty-four hours. In an aseptic wound, as a rule, one-half of the stitches are removed on the sixth or seventh day and the remainder on the eighth day, but for two weeks more the wound should be rested and supported, as the new tissue is not very resistant to infection. *Aseptic fever* always arises when much exudation is poured out and not quickly and perfectly drained. Aseptic fever is due to the absorption of aseptic pyrogenous material (page 124). If an incised wound becomes infected, the pyogenic organisms destroy the bond of union which is forming between the wound edges by liquefying the intercellular substance. As a consequence, the wound edges are widely separated by pus.

What used to be known as "*healing by blood-clot*" is healing by first intention. If there is a considerable gap between the edges of an aseptic wound, and the gap is filled with a blood-clot, healing goes on in the same manner as when the gap is narrow, although more corpuscles, more exudate, and more fibroblasts are required to effect repair.

Healing by Second Intention.—Healing of a wound in which there is a large cavity in the tissue or in which the edges have gaped apart is known as healing by granulation, or healing by "second intention." It is called healing by granulation because the granulations (areas of vascularized embryonic tissue) are visible. It is effected in the same manner as healing by "first intention," the processes in the two cases being practically identical if pus is absent. As a matter of fact, in healing by granulation there is usually wound infection. As a result of infection intercellular substance is peptonized, many reparative cells are cast off, and repair can be effected only after the formation of enormous numbers of fibroblasts and the expenditure of considerable time. It requires much longer for an infected wound to heal than for an incised wound to be repaired, and an infected wound can heal only by granulation. A short time after the infliction of a wound the oozing ceases because thrombi form in the vessels and some clot gathers in tissue-gaps and interstices. Exudation begins and leukocytes migrate into the exudate and into the walls of the wound. In an hour or two the surface of the wound becomes distinctly glazed or glistening, because of the formation and coagulation of fibrin. The exudation is at first thin and red, and it becomes so profuse as to wash away the discolored fibrin coat. In a few days the discharge usually becomes purulent. The connective-tissue cells, especially the endothelial cells of the vessels, proliferate and form fibroblasts, and the fibroblasts multiply to close the wound. From adjacent capillaries new capillaries form. This formation takes place as follows: A portion of a capillary thickens and a whip-like process comes off from the thickened part. This process fuses with a second filament budded from another or from the same capillary, or runs straight out as a terminal vessel. The filaments after a time are hollowed out from within, protoplasmic tubes are formed, and endothelial cells develop from the protoplasm. In some cases a tubular prolongation comes off from a capillary directly. Figs. 59 and 60 show the formation of a capillary. In a wound healing by granulation these newly-formed capillaries run among the fibroblasts, and some of them run perpendicularly to the surface, or a loop forms and reaches the surface. The surface of a granulating wound is covered with migrated leukocytes, and directly under

these are fibroblasts covering the new vascular strings or loops. Vascular strings or loops coated with fibroblasts are called granulations (Fig. 62 shows a granulating surface). When the discharge becomes purulent, many leukocytes and fibroblasts are destroyed, inflammation increases, exudation becomes profuse, and cellular multiplication widespread and rapid in order to

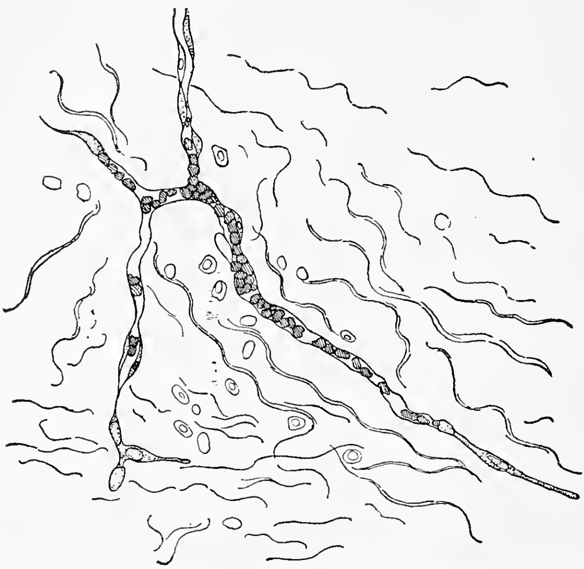


Fig. 60.—Development of a blood-vessel in mesentery of an embryo (Warren).

make up for the cells lost by microbic action. Gradually the gap is filled. As it is being filled the older fibroblasts in the deeper layers of the edges and base of the wound are converted into *cicatricial*, *fibrous*, or *scar tissue*. (Fig. 61.) As the granulations rise to a higher level at the surface the area of fibrous tissue becomes broader at the base and margins, and this young fibrous tissue contracts. By contracting it draws the edges of the wound nearer together and thus lessens the area of the surface which must be covered with epithelium. When the granulations reach the level of the cutaneous surface the epithelial cells at the margin of the wound proliferate, and young epithelial cells, constituting a bluish or opalescent film, grow over the granulations. Epithelium comes only from epithelium. Granulations are never converted into epithelium. The epithelial covering comes only from the epithelium at the wound margins, unless there be epithelial remains

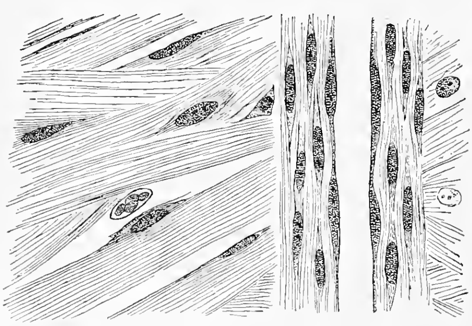


Fig. 61.—Cicatricial tissue; × 670 (Fowler).

in the wound; for instance, an undestroyed papilla, sweat-duct, or hair follicle. The process of covering the surface with epithelium is known as *epidermization.* The epidermization of a large area always consumes considerable time and sometimes Nature fails to accomplish it. In such cases skin-grafting is employed (*q. v.*). Before, during, and for a time after epidermization the fibrous tissue of the walls and base of the wound contracts. Thus the wound margins are pulled and held nearer together, the gap to be bridged is diminished in size, the danger of tearing apart of the epithelial coat is lessened, many capillaries are destroyed by pressure, and the scar becomes firm, white, and puckered. *Cicatrization* consists in the conversion of immature connective tissue into mature fibrous tissue and in the contraction of the new fibrous tissue. If infection is severe, destruction will exceed repair and healing will not occur. In such a case there is coagulation necrosis of granulation tissue, and the wound becomes covered with tissue remains (aplastic lymph). If granulations rise above the cutaneous level, healing will not take place, because the epithelium cannot then grow over the raw surface. A wound in this condition is said to possess *exuberant granulations,* or *proud flesh.* In some cases the granulations are *pale* from insufficient blood-supply, and in others *edematous* from venous congestion. Contraction of the fibrous tissue may be insufficient because there is adhesion to deep unyielding fascia or to periosteum. Excessive contraction is frequent after burns, often produces terrible deformity. The scars or cicatrices of burns contain much elastic tissue. Infected wounds and ulcers heal by second intention.

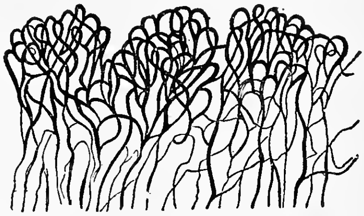


Fig. 62.—Blood-vessels in granulation (Gross).

Healing by Third Intention.—This consists in the union of two granulating surfaces, the granulations of one side fusing with the granulations of the other side. It is seen in the union of collapsed abscess-walls. The surgeon occasionally seeks to obtain union of a wound several days old by third intention by approximating two granulating surfaces. If the surfaces are aseptic, he will often succeed. The process follows what is known as *secondary suturing.* It is not unusual to pack a wound with iodoform gauze to control oozing. When this is done it is customary to pass the sutures, but not to tie them. After a few days the gauze is removed and the sutures are tied. This plan renders healing much more rapid than would be possible by the process of healing by second intention.

Cicatrices or Scars.—The newly-formed connective tissue which constitutes a scar will be present in large amount if more granulations were found than were really necessary for repair of if a considerable defect was repaired.

A recent scar contains fibrous tissue, many fibroblasts, and numerous blood-vessels but no nerves, lymphatics or elastic fibers. The skin above recent scars is usually red because of the numerous vessels beneath it and the layer of epidermis is well developed. In old scars fibroblasts have disappeared and fibrous tissue really constitutes the cicatrix. Some blood-vessels disappear and the diameters of those remaining are much reduced. These vascular changes result from contraction of the cicatrix. Delicate elastic fibers appear in old

scars. They appear at the end of the second month in wounds healed by first intention, at the end of the third or fourth month in wounds healed by second intention, and they take origin directly from cell protoplasm and not from fibrous tissue (Minervini, in "Virchow's Archiv," vol. 175, No. 2). No genuine lymphatics exist in old scars but occasionally nerve filaments are present. Some dermal papillæ are found after a time, but skin glands, skin muscle, and hair follicles remain absent.

An old scar is smooth, whiter than the surrounding skin, somewhat creased or wrinkled and deficient in tactile sense. The scar of a healed tuberculous ulcer is irregular, livid, and often actually corrugated. The scar of a healed syphilitic ulcer is at first coppery-red and then glistening white and depressed. The scar of an old ulcer of the leg and of the skin about it is often darkened by pigmentation.

A cicatrix may be discolored by retained foreign bodies, for instance, grains of gunpowder.

During scar formation shreds of epidermis may be displaced and included in granulation tissue. Subsequently they are included in fibrous tissue and may then give rise to transplantation (*implantation*) dermoids or to epithelial tumors. A scar may be deformed, for instance, may be greatly depressed and adherent to underlying bone, and in certain situations such a scar will fix the jaws or any other joint. The *vicious cicatrix* is a great excess of a scar tissue and results from delayed healing by second intention. Such cicatrices are particularly common after burns and tuberculous ulcerations. In some cases the scar is irregular and lumpy, in other cases it is thickened at certain parts and discolored and resembles keloid.

A cicatrix may block a natural orifice, as the mouth or nostril; may produce great deformities, for instance, the head may be drawn upon the chest or shoulder by a contracting scar in the neck, fingers may be grown together after a burn, or a hideous depression may exist on the forehead after an injury, or the face may be fearfully contorted by contracting cicatrices. A scar may produce great disability by blocking the jaws, obstructing the rectum or urethra, or fixing a joint or certain muscles of an extremity.

Most scars are insensitive, some are hypersensitive. The hypersensitive scars are usually thin and pale. The itching, burning or tingling appreciated in a sensitive scar are located, as a rule, at the junction of sound skin and newly-formed epidermis. Sometimes acute neuralgic pain exist in and about a scar due to pressure upon nerve filaments.

A scar may inflame or ulcerate, warts may spring from its cutaneous surface, keloid may arise from the fibrous tissue, carcinoma may come from the epithelial elements (Marjolin's ulcer), sarcoma from the connective-tissue elements.

Healing of Subcutaneous Wounds.—Blood fills the tissue gap and the blood-clots. Plasma exudes and corpuscles migrate into the clot and the tissue about it. The clot is eaten up by the leukocytes. The connective-tissue cells and the endothelial cells of the adjacent tissue proliferate and form fibroblasts, and fibroblasts multiply and replace the clot. The area of fibroblasts is vascularized by the formation of new capillaries, and fibrous tissue forms and strongly contracts.

Healing of Wounds in the Non-vascular Tissues.—In a trivial injury

of the cornea a few leukocytes gather from the lymph-spaces and a few of the fixed cells proliferate. When the cornea is more severely wounded, an increased flow of lymph occurs. The nerves are irritated, vessels adjacent to the cornea distend, and many leukocytes invade the lymph spaces. The corneal corpuscles multiply and alter in shape. The product of the process may be transparent if fibrin is absorbed and leukocytes pass away, because proliferating corneal corpuscles form transparent tissue. The surface epithelium is replaced by proliferation of the deep layer of corneal epithelium. If the wound has penetrated the posterior portion, it is filled by proliferating epithelium from the membrane of Descemet. In a severe injury of the cornea endothelial cells and corneal corpuscles proliferate, vessels grow in from the corneal margins toward the seat of inflammation, fibrous tissue forms, and permanent opacity results.

Repair in cartilage, if it occurs at all, is very slow and is accomplished in the same way as repair in the cornea. Any severe injury is repaired by white fibrous tissue, furnished by the cells of the perichondrium, and the scar is permanent.

Cell-division.—The multiplication of connective-tissue cells in repair may be by direct, but is usually by indirect, cell-division. *Direct cell-division* consists in division of the nucleus followed by division of the entire cell.

Indirect cell-division, or *karyokinesis*, takes place after remarkable changes in the nucleus. The membrane of the nucleus disappears; the nuclear network becomes first close and then more open; and the cell becomes round, if not so before. The network of the nucleus, now consisting of one long fiber, takes the shape of a rosette; next it takes a star form—the aster stage; two sets of V's next form—the equatorial stage; an equatorial line appears and widens, and each set of V's retreats toward a pole. Thus two new nuclei are formed, each polar V passing in inverse order through the previous changes of shape, and the protoplasm of the original cell collecting about each nucleus (Fig. 63).

Repair of Nerve.—A nerve-fiber consists of a core known as the axis-cylinder, which is the essential element in function. About the axis-cylinder is an almost liquid material, known as the medullary sheath or white substance of Schwann, or myelin. The myelin is surrounded by a firm sheath known as the neurilemma (sheath of Schwann, primitive sheath, neurolemma). On its inner surface, or between it and the white substance of Schwann, are nuclei which are supposed by some to be peripheral nerve-cells (neuroblasts). The neurilemma is absent in the brain and cord. The continuity of the white substance of Schwann is interrupted at frequent intervals, and these breaks in the myelin are called nodes of Ranvier. Numbers of fibers of the kind just described, bound into bundles by connective tissue and surrounded by a fibrous sheath, constitute a nerve. It is known that a nerve may be regenerated and completely regain function after division; that regeneration is strongly favored by suturing the ends together; and that if the ends of a divided nerve are more than one inch apart, regeneration will rarely take place unless they are sutured together. The method by which regeneration is affected has been much disputed and is still involved in uncertainty. If a nerve is divided, the peripheral segment at once loses its function and then undergoes degeneration (Wallerian degeneration). The degeneration begins within

twenty-four to forty-eight hours and affects the entire peripheral segment. The axis-cylinder perishes, the myelin runs into globules and is absorbed, leaving an almost empty sheath; the nuclei of the inner surface of the neurilemma proliferate for a time, but cease to do so before the myelin is completely absorbed. The sheath shrinks and looks empty, but here and there are collected masses of proliferated nuclei and protoplasm. Degeneration takes place in days, but regeneration requires months. Regeneration takes place by the multiplication of pre-existing nerve-fibers and not by the transformation of connective tissue into nerve structure. The ends of a divided nerve, it is true, are united by connective tissue formed by the proliferation of fibroblasts, but this connective tissue is only a bridge to carry nerve elements across the gap between the proximal and peripheral segments. The common view is that regeneration takes place as follows: The new axis-cylinder of the peripheral segment is a prolongation of the old axis-cylinder of the proximal segment, projected in the following manner. A fiber, which is at first devoid of myelin, is prolonged from a proximal axis-cylinder; it divides into many cylinders, which pierce the granulation tissue between the ends and enter into the empty sheaths of Schwann of the distal segment or insinuate themselves between these sheaths (Ranvier, Réclus, Senn). The above is the view entertained by those who teach that the new axis-cylinders come entirely and only from the prolongation of old axis-cylinders of the proximal segment, and that the distal segment is passive in the process until "neurotised" (Vanlair), and that regeneration is impossible in the distal segment unless it is in approximation with the proximal segment or within easy reach of the prolongations of the axis-cylinders from above. Another view is that the axis-cylinders, myelin, and neurilemma are formed from cells which exist in the distal segment, and that juvenile axis-cylinders and medullary sheaths are formed in the peripheral portion and then effect a junction with like structures of the central segment. The last-mentioned view is advocated by Mayer and Eichhorst, Tizzoni, Cattani, and others, and Ballance and Stewart have recently published a most valuable monograph advocating it ("The Healing of Nerves"). The nuclei proliferate and form a mass of protoplasm within the old sheath, which protoplasm joins the proximal segment. Such a protoplasmic fiber has "conduction and irritability" (Raymond's "Human Physiology"), but there is as yet neither myelin nor axis-cylinder. "The fiber is responsive to mechanical stimuli, but not to induction shocks, which latter property returns only after the axis-cylinder is developed. The medullary substance later appears and forms a tube; and still later the axis-cylinder is formed, having its origin in the central end of the nerve" (Raymond's "Human Physiology"). The views of Ballance and Stewart may be set forth as follows: When a nerve-trunk is divided, the peripheral segment degenerates whether it has been sutured to the proximal segment or not, and the portion of the proximal segment near the wound also degenerates. The injury produces at once an effusion of blood, migration of leukocytes takes place into and about the wound at the proximal segment, but leukocytic invasion of the entire distal segment is noted. After three days connective-tissue cells begin to replace the leukocytes, and after two weeks the excess of leukocytes is no longer observed, proliferated connective-tissue cells having taken their place (page 94, "Healing of Nerves"). The proximal segment in the neighborhood of the wound

and the entire distal segment are invaded by proliferating connective-tissue cells. The connective-tissue cells completely absorb the fatty myelin and axis-cylinders. The cells of the neurilemma actively multiply, and connective-tissue cells lying among chains of neurilemma cells become spindle-shaped and "the degenerated nerve-trunk therefore becomes hard, fibrous, and cirrhosed" (Ballance and Stewart on the "Healing of Nerves," page 94).

In the proximal end of a divided nerve an "*end-bulb*" is formed. This was long supposed to be due to the prolongation of nerve-fibers from the central fibers and a turning backward because they cannot cross the gap. As a matter of fact, the ends of the divided fibers curl up; on and in this scaffold-like arrangement new fibers are placed, they having been produced by the neurilemma cells which have taken on "neuroblastic function" (Ballance and Stewart). When a nerve has been sutured, the earliest signs of regeneration "occur at the end of three weeks" (Ballance and Stewart). Short lengths of new fibers are laid down within old neurilemma sheaths. The new axis-cylinder "is seen to consist in the deposition along one side of a spindle-shaped neurilemma cell, of a thin thread which grows in length until it projects beyond the limits of the parent cell and stretches on toward its next neighbor in the same longitudinal row" (Ballance and Stewart). The new medullary sheath is "laid down by a process of secretion" (Ballance and Stewart) along the sides of the neurilemma cells.

Ballance and Stewart go on to point out that if the central theory of regeneration is true, not a trace of regeneration could occur in the distal segment when the two segments have not been united by sutures, and yet such regeneration *does* occur, although slowly, the new axis-cylinders and medullary sheaths not attaining full size. "Evidently some stimulus afforded by the conduction of impulses is necessary in order to permit of their full development" (Ballance and Stewart). In the notable study quoted at such length are some experiments on the "conduct and fate of transplanted nerve." When the gap is wide between the two ends, a portion of fresh nerve-trunk may be inserted to bridge it. The transplanted piece degenerates; it is invaded by leukocytes, and proliferating connective-tissue cells, medullary sheaths, and axis-cylinders are destroyed, but regeneration may subsequently occur; "but when it does occur, it is not from the activity of the cells of the graft itself" (Ballance and Stewart). Blood-vessels enter the degenerated graft at each end and they are accompanied by chains of neurilemma cells, which form axis-cylinders and medullary sheaths. The graft is merely a scaffold (Ballance and Stewart).

The studies of Ballance and Stewart persuade us that regeneration does occur in the distal part independently of the proximal part, although full development does not take place unless there is a junction with the central part. As to the exact method of regeneration we still feel somewhat uncertain. When we remember that the nerve-fibers of the spinal cord are devoid of neurilemma and that the cord can, to some extent at least, regenerate, we must conclude that regeneration can take place in the cord without the aid of neurilemma cells, and must infer that the same may be true in a nerve.

Repair of the Spinal Cord and Brain.—Can the spinal cord regenerate? Many observers have doubted it. But there is no doubt of the fact that sometimes, after the subsidence of an acute myelitis or after the relief of a pressure

which produced complete and prolonged paralysis, there is a return of functional power. It is usually assumed that restoration is possible in fibers which have not been hopelessly damaged, but is not possible in those which have been destroyed; but, as Gowers says, there are cases in which "we can scarcely believe that the axis-cylinders retain their continuity, although conducting capacity is ultimately restored." Clinical evidence indicates strongly that the pyramidal fibers may regenerate. Mills says ("The Nervous System and Its Diseases"): "Nerve-tracts in the spinal cord and brain have power to regenerate, but this is not so great as in the peripheral nerves, and yet even old cases of compression of the spinal cord may make great improvement after a long time, largely through the regeneration of the columns of the cord." Mills affirms that although nerve-cells sometimes appear to regenerate, the destruction in these cases was not complete.

When axis-cylinders have been destroyed in the cord and yet some power returns, we ask ourselves if this occurs because new fibers have grown down from above. Gowers says that such a growth has been proved to occur in the lower animals, but has not as yet been demonstrated in man; although specimens have been described which strongly suggest such an occurrence in the human subject. That the cord can regenerate to some extent seems highly probable from the report of a recent case. Dr. Francis T. Stewart, of Philadelphia, sutured a completely divided spinal cord and an extraordinary restoration of function took place (Francis T. Stewart and Richard H. Harte, in "Phila. Med. Journal," June 7, 1902). This case is commented on at some length in the section on Injuries of the Spinal Cord. Another somewhat similar case was reported by George Ryerson Fowler in the "Annals of Surgery," Oct., 1905.

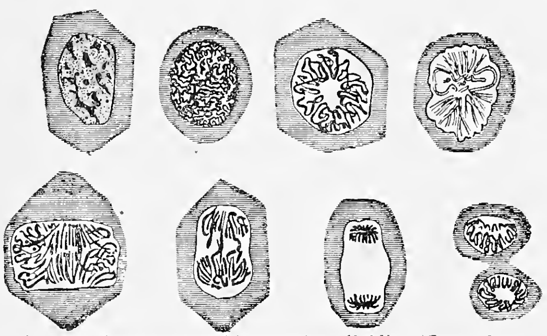


Fig. 63.—Forms assumed by a nucleus dividing (Green, from Flemming).

Many claim that a brain injury cannot be followed by repair with restoration of function; some think that complete regeneration can take place; others, that partial regeneration may occur. Vitzon and Tedeschi even believe that nerve-cells in the brain can regenerate. It seems probable that extensive injuries are not repaired, but slighter ones may be, new ganglion-cells and neuroglia being formed. Tedeschi describes the process of repair after a wound of the brain as follows: Degeneration occurs and a limited focus of necrosis forms and then the adjacent tissue shows evidences of repair. Capillaries form from the endothelial cells, glia tissue from the neuroglia, ganglion-cells present karyokinetic changes, and some nerve-fibers appear in the scar (Senn's "Principles of Surgery").

Repair of Muscles.—It has long been taught that the repair of muscle by muscle is impossible, and, as a matter of fact, it does not take place if the ends of a divided muscle are separated to the extent of an inch or more. When

a muscle is divided transversely by a considerable cut, the ends retract and a wide space is left between them. Blood flows into the space between the ends and also between individual fibers of the injured muscle, and the blood-clots. Exudation of plasma occurs and migration of curpuscles takes place. Fibroblasts are produced by proliferation of connective-tissue cells and a mass of fibroblasts soon replaces the blood-clot. Granulation tissue is formed by vascularization of the mass of fibroblasts, and granulation tissue is converted into scar tissue, but not at all into muscle. After slight injuries a trivial amount of muscular regeneration does occur by the multiplication of living muscle-cells, but not by metamorphosis of fibroblasts. Fibroblasts are in-

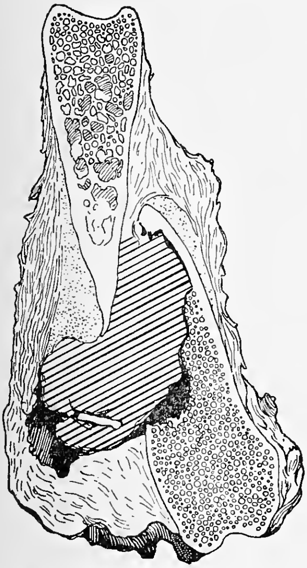


Fig. 64.—Fracture one week: blood-clot containing fragment of bone (Warren).

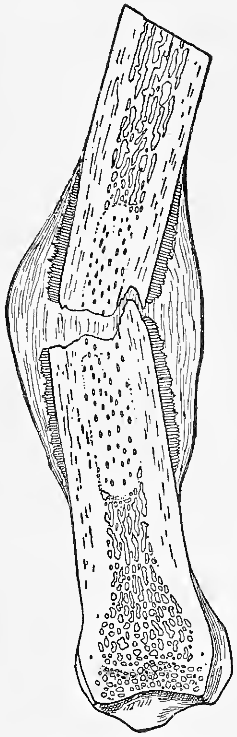


Fig. 65.—Callus of fracture (dog) four weeks: commencing ossification of external callus (Warren).

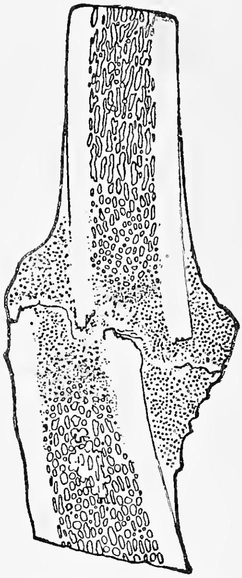


Fig. 66.—Femur of a child fifth week after fracture (Warren).

capable of a transformation into muscular tissue. When the ends of a divided muscle are separated only to a very slight degree or when they have been brought together and sutured, some muscular regeneration occurs. After an injury a number of the muscular fibers wither, perish, and are absorbed. The process of regeneration arises from the remaining fibers. The nuclei of the muscle-fiber proliferate and so do the nuclei of the perimysium. The muscle-cells are called myoblasts and the nuclei of the perimysium are called sarcoblasts. About the juvenile muscle-cells a deposit of protoplasm takes place (Weber). The embryonal cells gradually become spindle-shaped and muscular fiber is formed by cellular fusion or by elongation of individual cells.

The above remarks refer to striated muscle. Unstriated muscle fibers are repaired solely by "indirect multiplication of their nuclei" (Senn).

If a muscle has been divided, it should be sutured. This process insures more rapid repair and secures a better functional result, and is followed by a much greater amount of muscular regeneration.

Repair of Tendon.—When a tendon is divided, the ends retract, and the sheath, as a rule, becomes filled with blood-clot. The blood-clot is rapidly removed, fibroblasts replacing it. This new tissue arises from the sheath, the cut ends of the tendon not participating in its formation. Granulation tissue is formed; this is converted into fibrous tissue, and after a time the fibrous tissue becomes true tendon. If no blood-clot forms in the sheath, the walls of this structure collapse and adhere, and the separated tendon-ends are held together by a flat fibrous band formed from the collapsed sheath (Warren's "Surgical Pathology").

Repair of Bone.—When a bone is broken, a blood-clot quickly forms in the medullary cavity, between the broken ends and under and outside the periosteum. Leukocytes invade and destroy the clot. The cells outside the periosteum, the cells of the periosteum and of the medullary tissue, particularly the endothelial cells, proliferate and produce cells which are practically fibroblasts. The osteoblasts in the medullary tissue and in the deeper layers of the periosteum multiply and are distributed through the mass of fibroblasts. The osteoblasts may form bone directly or may form cartilage first. Some teach that fibroblasts can be converted into bone; others positively deny such a conversion. The point is not settled, but it is well to remember that in myositis ossificans a muscle is converted into bone, and hence that it is probable that fibroblasts, formed from periosteum and medullary tissue, should be much more prone to undergo such a development. During regeneration the bone ends soften and are partially absorbed by osteoclasts. These cells are large osteoblasts which have lost the power of bone production and furnish a secretion which dissolves osseous matter. The excess of callus is finally absorbed by osteoclasts. (For a more extended description see Repair of Fractures.)

Repair of Blood-vessels.—If an artery is cut across and ligated, a clot forms within its lumen and about its divided end, and the circulation in the vessel at this point is permanently arrested. The proximal clot, it used to be thought, always reaches the first collateral branch. This statement was true before the days of asepsis; it is not always true now. Often a clot stops far short of the branch above. Exudation of plasma and migration of corpuscles take place from the vasa vasorum. The clot becomes filled with leukocytes, which gradually destroy it, and it plays no active part in repair. Fibroblasts form by the multiplication of the cells of the vessel wall and the clot is soon replaced by fibroblasts. The fibroblasts are converted into granulation tissue, granulation tissue becomes fibrous tissue, the fibrous tissue contracts, and the artery is transformed into a fibrous cord (Fig. 183). Warren insists that the muscle-cells of the middle coat play an active part in repair. Usually, when a ligature is applied to an artery in continuity, a deliberate attempt is made to rupture the internal and middle coats, in order to permit of contraction and retraction above and below the seat of ligature, and a turning inward of the inner coat. Such a sequence of events happens when an artery is completely divided across and not tied, and favors the rapid formation of a clot.

Ballance and Edmunds ("Ligation in Continuity") maintain that repair is obtained most rapidly when the artery is tied with two ligatures, the vessel at this point being deprived of blood, but the internal and middle coats being kept intact. Cell-proliferation forms a spindle-shaped mass of new cells and the lumen is obliterated at the seat of ligation by fibroblasts obtained from the fixed cells of the wall of the artery. Senn advocates the employment of two ligatures, not placed side by side as in the method of Ballance and Edmunds, but so applied as to include "a bloodless space about half an inch in length" (Senn's "Principles of Surgery").

When a lateral ligature is applied to a vein or when a small wound in a vein or artery is sutured, the circulation in the vessel is not completely cut off, a thrombus of small size is formed on the vessel-walls, the fixed cells of the vessel-wall proliferate, and a scar of fibrous tissue effects repair. A completely divided vein heals as does a completely divided artery (Fig. 184). The clot after the aseptic application of a ligature to a vein may be of slight extent, but in some cases the proximal clot reaches the first collateral branch and in others goes far above it.

Repair of Skin.—The fibrous structure is repaired by fibrous tissue. Hair follicles, sweat-glands, and sebaceous glands are not reformed. The epithelial layer is regenerated by the proliferation of adjacent epithelial cells.

Repair of Lymphatic Tissue.—Lymphatic tissue can regenerate either from the fatty tissue, the divided ends of the lymph ducts or both structures.

Repair of the Kidney and Testicle.—These organs when damaged can undergo some regeneration.

Repair of the Liver and Spleen.—Each of these organs, after injury, is capable of considerable regeneration.

V. SURGICAL FEVERS.

The surgeon encounters fever as a result of an inflammation or an aseptic wound, in consequence of infection, as a result of poisoning by certain drugs, and in several maladies of the nervous system. It is important to remember that, while elevated temperature is generally taken as a gauge of the intensity of fever, it is not a certain index. There may be fever with subnormal temperature (as in the collapse of typhoid or pneumonia), and there may be elevated temperature without true fever (as in certain diseases of the nervous system). It is true, however, that elevation of temperature is almost always noted, and is usually accepted as the measure of the severity of the fever.

The essential phenomena of fever, according to Maclagan, are—(1) wasting of nitrogenous tissue; (2) increased consumption of water; (3) increased elimination of urea; (4) increased rapidity of circulation; and (5) preternatural heat.

Traumatic fevers follow a traumatism and attend the healing or infection of a wound. The forms are —(1) benign traumatic fever; (2) malignant traumatic fever.

Benign traumatic fever is divided into two forms—the *aseptic* and the *septic*. There is but one form of aseptic fever, the post-operation rise. The septic benign fevers are surgical fever and suppurative fever. The malignant

traumatic fevers are sapremia, septic infection, and pyemia. In this section we discuss only the benign fevers.

Aseptic traumatic fever, or the *post-operation rise*, often, but not always appears after a thoroughly aseptic operation and after a simple fracture or a contusion. It is not preceded by a chill, by chilliness, or by a feeling of illness. It may appear during the evening of the day of operation or not until the next day, and reaches its highest point by the evening of the second day (100° to 103° F.). This elevation is spoken of as the "post-operation rise" because it is usually encountered after an operation. Besides the elevated temperature there are no obvious symptoms; the patient feels well, sleeps well, and often wants to sit up; there are no rigors and there is no delirium. The wound is free from pain and appears entirely normal. But examination may show moderate leukocytosis. This fever is due to absorption of pyrogenous material from the wound area, the material being obtained from clot or inflammatory exudate, or from both. Many observers believe that the pyrogenous element is fibrin ferment, which is absorbed from disintegrating blood-clot and coagulating exudate. Warren thinks the fever is due to fibrin ferment, and "also to other substances slightly altered from their original composition during life." Some have asserted that the fever is due to nervous shock.

Schnitzler and Ewald have recently studied aseptic fever.* These observers maintain that aseptic fever can exist when no fibrin ferment is free in the blood, that fibrin ferment can be free in the blood when there is no fever, and, in consequence, that fibrin ferment is not the cause of the elevation of temperature. They rule out of consideration nervous shock as a cause, and assert that a combination of several factors is responsible, nucleins and albumoses which are set free by traumatism being looked upon as the most active causative agents. The presence of nuclein in the blood in aseptic fever is indicated by leukocytosis and by the increase of the alloxur bodies (including uric acid) in the urine. The capacity of nucleins and albumoses to cause fever is greater in the tuberculous than in the non-tuberculous, and we know clinically that a tuberculous patient is apt to exhibit a more violent post-operation rise than is a non-tuberculous subject. The diagnosis of aseptic traumatic fever is only to be made after a careful examination has assured the surgeon that there is no obscure or hidden area of infection.

In some cases aseptic fever may appear after an operation, and later be replaced by a septic fever. If the temperature remains high after a few days, if other symptoms appear, or if after the temperature has become normal it again rises, the wound should be examined at once, as trouble almost certainly exists.

True traumatic or **genuine surgical fever** is seen as a result of infected wounds in which there is decided inflammation, but no pus. The real cause is the presence of fermentative bacteria in the wound and the absorption of a moderate amount of their toxic products. The most active and commonly present organisms are those of putrefaction. Surgical fever ceases as soon as free discharge occurs, and the appearance of such a fever is an indication for instant drainage. The condition is ushered in two or three days after the operation by chilly sen-

*See Archiv für klinische Medicin, Bd. liii, H. 3, 1896; also statement of their views in Medical Record, Dec. 19, 1896.

sations and general discomfort. The temperature rises pretty sharply, ascends with evening exacerbations and morning remissions, and reaches its height about the third or fourth day, when suppuration sets in; the temperature begins to drop when pus forms, if the pus has free exit, and reaches normal at the end of a week (see Suppurative Fever). The temperature may reach 104° F. or more, but rarely rises above 103° F. The patient has the general phenomena of fever, that is to say, thirst, anorexia, nausea, dry and coated tongue, constipation, pain in the back and legs, and headache. The urine is scanty and high-colored. Blood examination usually shows decided leukocytosis. The wound is painful, tender, swollen, discolored, and often foul, and stitch-abscesses may form. Some or all of the stitches must be cut, and the area should be asepticized, and packed with iodoform gauze or drained by a tube. The fact that this fever is apt to cease when discharge of pus begins led the older surgeons to hope for pus and to endeavor to cause it to form. A severe grade of surgical fever, such as arises when there is putrefaction in a large and ill-drained wound, is due to the absorption of a large quantity of the toxic products of putrefactive bacteria and is known as sapremia (page 195).

Suppurative Fever.—This fever, which is due to the absorption of the toxins of pyogenic organisms, occurs after suppuration has begun, is found when the pus has not free exit, and is an intoxication rather than an infection. It can follow or be associated with surgical fever, or may arise in cases in which surgical fever has not existed. Suppuration in a wound is indicated by a rapid rise of temperature—possibly by a chill. The temperature rises to a considerable height, shows morning remissions and evening exacerbations, and as it begins to fall toward morning sweating occurs. The patient is much exhausted and presents the phenomena of fever previously described. The skin about the wound becomes swollen, dusky in color, and edematous, pain becomes pulsatile, and much tenderness develops. Blood examination shows very marked leukocytosis. The wound must at once be drained and asepticized. In a chronic suppuration, such as occurs when there is pyogenic infection of a tuberculous area, there exists a fever with marked morning remissions and vesperal exacerbations, attended with drenching night-sweats, emaciation, diarrhea, and exhaustion. This is known as *hectic fever;* it is really a chronic suppurative fever. The treatment of hectic fever consists in the drainage and disinfection, if possible, the excision of the infected area, the employment of a nutritious diet, stimulants, tonics, remedies for the exhausting sweats, and free access of fresh air.

Some Other Forms of Fever Seen by the Surgeon.—Fever of Tension.—When there is great tension upon the stitches the spots where the stitches perforate ulcerate and some fevers arise. To relieve the fever of tension cut one or several stitches. This fever is in some cases surgical, and in some suppurative, according as to whether the infective organisms cause fermentation or suppuration.

Fever of Iodoform Absorption (see page 30).

Fever of Ptyalism, or **Mercurial Fever** (see page 291).

Fever of Morphinism.—Sometimes a morphia habitué suffers from severe chills and intermittent fever of the quotidian or tertian type. The condition is usually thought to be malarial, a view which is strengthened by the

common association with neuralgia; but quinin proves futile as a remedy and blood-examination gives a negative result. If we have reason to suspect that the patient is using morphia, examine the urine for the drug and wash out the stomach and examine the washing. The latter test is of value even when morphin is used hyperdermatically, because that drug is excreted into the stomach.

Fever of Cocain-poisoning (see Local Anesthesia).

Hepatic Fever (see section on Liver and Gall-bladder).

Hysterical Fever.—This remarkable condition is occasionally, though seldom, encountered. Most of the reported cases of great hyperpyrexia are instances of simulation and fraud. It may happen that elevated temperature is the sole evidence of illness, there being no wasting or other febrile symptoms. Such elevated temperature may be attained daily for months. As a rule, hysterical stigmata can be detected. Osler points out that cases of hysterical fever "with spurious local manifestations" are very deceptive. The case may resemble meningitis, peritonitis, or some other acute inflammatory condition; but the course of the supposed malady is found to be atypical and the symptoms are observed to be variable and often anomalous. There is no leukocytosis; frequently there is an apparent increase in red cells because of vasomotor disturbance, a fall in hemoglobin, and an increased proportion of lymphocytes and eosinophiles ("Clinical Hematology," by J. C. DaCosta, Jr.).

An **emotional fever** sometimes occurs after accidents or operations. The patient may have a chill, and then develop violent headache, photophobia, and hysterical excitement, with elevated temperature.

Malaria.—It is wise to examine the blood in supposed septic fevers, for only by this means can malaria be excluded. It is more common to mistake sepsis for malaria than malaria for sepsis. In malaria the spleen is enlarged, the febrile attacks exhibit periodicity, neuralgias are common associates, and quinin cures the condition.

Surgical Scarlet Fever.—It is maintained by some writers (notably Sir Victor Horsley and Sir James Paget) that a child is rendered especially susceptible to scarlet fever by the shock of a surgical operation. Scarlet fever which develops after a wound, a burn, or an operation is spoken of as surgical scarlet fever. Warren quotes Thomas Smith as having had ten cases of scarlet fever in forty-three operations of lithotomy in children. The puerperal state is supposed also to predispose to scarlet fever. It is not certain whether the poison enters by the wound, or whether shock and exhaustion predispose to ordinary scarlatina, or whether ordinary scarlatina was incubating before the accident or operation. Some surgeons hold that an attack of scarlet fever after an operation is a mere coincidence. Others maintain, and with great show of reason, that a red scarlatiniform eruption appearing after an operation, rarely indicates genuine scarlet fever, but usually points to infection, as such eruptions are known occasionally to arise in septicemia. It *rarely* indicates scarlet fever, and yet it sometimes does. There is such a condition as surgical scarlet fever, as is proved by the facts that victims of the disease have been known to communicate it, and that it is often followed by "nephritis and usually by desquamation" (Holt's "Diseases of Infancy and Childhood").

Hoffa has discussed this subject elaborately. He concludes that four types of eruption can follow operation: (1) a vasomotor disturbance due to irritation of sensory nerves, and manifested by a transient urticaria or erythema; (2) a toxic erythema due to absorption of aseptic pyrogenous material from the injured area—the absorption of carbolic acid, iodoform, of corrosive sublimate, or the effect of ether; (3) an infectious rash which is sometimes found in septicemia or pyemia, and is due to minute emboli composed of bacteria, which emboli lodge in the capillaries; (4) true scarlet fever, with the usual symptoms and complications, the micro-organisms having entered by way of the wound and the eruption often beginning at the wound edges (quoted in Warren's "Surgical Pathology"). Surgical scarlatina is aberrant. It develops rapidly, the period of incubation is extremely brief, and the throat may or may not be involved. Holt tells us that the rash is usually atypical and that "the general symptoms, particularly those relating to the nervous system," are "especially severe" ("Diseases of Infancy and Childhood"). The infection is believed to be due to a specific germ, but it has not been certainly identified. Streptococci have been found in the throat, skin, and the pus from secondary otitis media.

If surgical scarlet fever develops the wound should be drained and asepticized, and if the situation admits of it, dressed with hot antiseptic fomentations. The general treatment is the same as for ordinary scarlatina.

Urinary Fever and Urethral Fever (see section on Disease of Genito-urinary Organs).

Syphilitic Fever (see page 279).

Thyroid Fever (see section on Thyroid Gland).

VI. SUPPURATION AND ABSCESS.

Suppuration is a process in which damaged living tissues and inflammatory exudates are liquefied by the action of pyogenic organisms, and it is a common result of microbic inflammation. The organisms which are responsible are referred to on page 42. Staphylococci tend to produce local suppuration; streptococci tend to cause spreading suppuration. It is generally taught that pyogenic bacteria liquefy damaged tissue and exudate by peptonizing them, the active agent in effecting the chemical change being poison furnished by the bacteria. There is some evidence that white corpuscles by disintegration set free enzymes which dissolve or aid in dissolving albumin. Streptococci and staphylococci vary greatly in virulence and the intensity and diffusion of a pyogenic infection depends upon the virulence and number of the bacteria and the level of vital resistance. Streptococci and staphylococci may both be present in one focus, and there may be secondary infection with bacteria of putrefaction or other bacteria. The pyogenic infection may be primary or it may be secondarily implanted in a diseased area containing other micro-organisms. The pyogenic organisms are very irritant, and when deposited cause inflammation; inflammation leads to exudation, but the exudate cannot coagulate or coagulates but imperfectly, because it is peptonized by the ferment of the micro-organisms and also perhaps because albumin is dissolved by leukolysin from the white corpuscles. If an area of embryonic tissue is

invaded by the pyogenic micro-organisms, it is promptly peptonized. The peptonizing action is upon the fibrinous elements of an exudate and upon the intercellular substance of embryonic or granulation tissue. Cells are separated from intercellular substance, and in consequence degenerate and die. Peptonized exudate or peptonized embryonic tissue is called pus. In suppurations induced by staphylococci a barrier of leukocytes is first formed around the region of irritation; this barrier is reinforced by fibroblasts, the pus is imprisoned, and rapid spreading and wide diffusion are prevented. In inflammations induced by streptococci the peptonizing action of the organisms is so great that no barrier of white blood-cells or of proliferating connective-tissue cells forms in time to imprison the micro-organisms; hence the suppuration spreads rapidly and widely. Suppuration can be induced by the injection of pyogenic bacteria, by their entry through a wound, and by rubbing them into the skin. In some rare instances, especially when the diet has been putrid, they may enter through the blood and lodge at a point of least resistance. When a medullary canal suppurates after a chill to the surface or after a blow that does not cause a wound, we know that the bacteria must have arrived by means of the blood. Bacteria which reach a point of least resistance through the blood come from some atrium of infection which may be discoverable or which may not be found. The entry of pyogenic bacteria does not necessarily cause suppuration, as the healthy human body can destroy a considerable number, even if given in one "dose"; but a large number in a healthy, or even a small number in an unhealthy body, almost certainly leads to pus-formation. The pus of all acute abscesses contains bacteria of suppuration, but the pus of tuberculous abscesses does not, unless there be a mixed infection; in other words, pure tuberculous pus is not pus at all.

Can suppuration be induced without the actual presence of bacteria? It is true that the injection of irritants can cause the formation of a thin fluid which contains no bacteria; but this non-bacterial fluid is not pus. A purulent fluid is formed by injecting cultures of pus cocci which have been rendered sterile by heat, the bacteria having been killed, and a ferment contained in the bacterial cells being the active agent. Purulent material also results from the injection simply of the sterile products of the growth of pyogenic cocci. This purulent or sterile fluid is known as *spurious* or *aseptic pus*. An area of such aseptic suppuration does not tend to spread and the process concerns us but little as surgeons, except in cases of pyemia in which thrombi containing toxins alone may occasionally induce limited secondary abscesses.

Impaired health or an area of lowered vitality predisposes to suppuration. Diabetes and albuminuria are common and influential predisposing causes, because in these diseases tissue resistance is always at a low ebb. The lymphatic glands, medulla of bones, serous membranes, and connective tissue are especially prone to suppurate.

Pus may form within twenty-four hours after bacteria have been deposited, or it may not be formed for days. The older surgeons claimed that pus could do good by protecting granulations and separating disorganized tissue. It is now held that it is absolutely harmful by melting down sound tissue and poisoning the entire organism. Modern surgery has to a great degree abolished pus.

If pus stands for a time, it separates into two portions—(1) a watery por-

tion, the liquor puris or pus-serum, containing peptone, fat, microbic products, osmazone, and salts, and not tending to coagulate; (2) a solid portion, or sediment composed of dead and living micro-organisms of suppuration, connective-tissue cells, often epithelial cells, perhaps red blood-cells, lymphocytes, pus-corpuscles (Fig. 67), débris of tissue, and shreds of dead tissue. The pus-corpuscles are either polynuclear white blood-cells or altered connective-tissue cells containing many nuclei. Some of them are dead, some have ameboid movements, some are fatty, others are granular and contain more than one nucleus, and all are degenerating. A pus-cell is waste matter, and it cannot aid in repair. Very exceptionally pus disappears by absorption, by caseation, or by calcification.

Pus in General.—The color of pus is variable and depends upon the nature of the bacteria; the presence or absence of blood, fibrin, body secretions

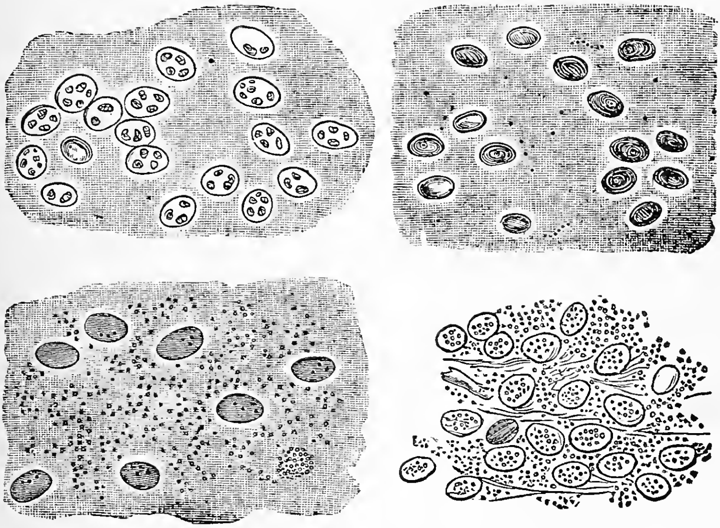


Fig. 67.—Fragmentation of nucleus in leukocytes undergoing transformation into pus-corpuscles (Senn).

or body excretions (bile, urine, mucus, feces, etc.); and the existence or nonexistence of putrefaction.

Its consistence varies. In some cases it is scarcely thicker than water, in others it is like cream and in still others it is cheesy. Thick pus is usually of a greenish-yellow color and thin pus has usually a reddish or yellowish tinge (Leonard Freeman). When freshly evacuated many varieties are almost or quite odorless, and are alkaline or slightly acid in reaction.

Some varieties possess a very offensive odor. Pus contaminated by the bacteria of putrefaction is certain to have a foul odor. Pus which forms in the tonsil, in the brain, about the vermiform appendix, or around the rectum usually possesses an offensive odor.

Forms of Pus.—*Laudable*, or *healthy pus*, a name long in vogue, is a contradiction, no pus being healthy. In former days free suppuration after an operation was regarded as a favorable indication, and when it occurred the

surgeon congratulated himself that surgical fever was at an end. At the present day suppuration after an operation is an evidence of previous infection, of lack of care, failure in our precautions, or of infection by the blood. The so-called *laudable pus* is seen coming from a healing ulcer, and is an opaque, yellowish-white, or a greenish fluid of the consistence of cream, without odor or with a very slight odor if it is not putrid, and having a specific gravity of about 1030.

Malignant, *watery*, or *ichorous pus* is a thin, watery, putrid fluid. It is pus filled with the organisms of putrefaction.

Stinking pus may be ichorous. Its odor may be due to the bacterium coli commune. If this bacterium is the cause the pus is very foul, but not thin. Pus of this nature is met with in ischiorectal abscess and appendiceal abscess. Its odor may be due to ordinary bacteria of putrefaction, in which case the pus is thin.

Sanious pus is a form of ichorous pus containing blood coloring-matter or blood. It is thin, of a reddish color, and very acrid, corroding the parts that it comes in contact with. It is found notably in caries and carcinoma.

Concrete or *fibrinous pus*, which contains flakes of fibrin or coagulated fibro-purulent masses, is met with in serous cavities (joints, pleura, etc.). These masses also form in infective endocarditis.

Red pus signifies the presence of the bacillus prodigiosus.

Blue Pus.—The color of blue pus is due to the bacillus pyocyaneus.

Orange Pus.—The color of orange pus is due either to the action of sarcina aurantiaca, or to the formation of crystals of hematoidin from the coloring-matter of red blood-cells which have been mingled with the pus. Pus of this color appears only in violent inflammations.

Serous pus is a thin serous fluid containing a few flakes.

So-called *tuberculous*, *scrofulous*, or *curdy pus* is not pus at all, unless the tuberculous area has undergone pyogenic infection.

So-called *gummy pus* arises from the breaking down of a gumma which has outgrown its own blood-supply. It is not pus.

Muco-pus is found in purulent catarrh—that is, in suppurative inflammation of an epithelial structure. It contains pus elements and epithelial cells.

Caseous pus comes from the fatty degeneration of pus-corpuscles or inflammatory exudations. It occurs especially in tuberculous processes. A caseous mass may calcify.

Signs and Symptoms of Suppuration.—Suppuration is announced by the intensification of all local inflammatory signs. The heat becomes more marked, the discoloration dusky, the swelling augments, the pain becomes throbbing or pulsatile, and the sense of tension is greatly increased. The skin at the focus of the inflammation after a time becomes adherent to the parts beneath, and fluctuation soon appears. This adhesion of the skin is a preparation for a natural opening, and is known as *pointing*. An important sign of pus beneath is edema of the skin. This is always observed in a superficial abscess, and is sometimes noticeable in empyema or pyothorax, in appendiceal abscess, and in perirenal suppuration. The above symptoms can be reinforced and their significance proved by the introduction of an aseptic tubular exploring needle and the discovery of pus. Irregular chills, high fever, drenching sweats, weakness, and a feeling of serious sickness are very significant of suppuration in an important structure or of a large area. It must always be remembered that in

some virulent pyogenic infections the human organism is overwhelmed with toxins and although the patient is desperately ill the temperature is normal or even subnormal. In abscess of the brain the temperature may be normal or subnormal.

Diffused Cellulitis or Phlegmonous Suppuration; Purulent Infiltration.—This process may involve a small area or an entire limb, and is due to infection by the streptococcus pyogenes (or streptococcus of erysipelas) usually associated with mixed infection with other bacteria particularly the bacteria of putrefaction. The streptococci are intensely virulent. Barriers of white corpuscles will not restrain them, and tissues break down before cellular multiplication is able to encompass the bacteria. The bacteria disseminate through the lymph-spaces and lymph-vessels. The disease in severe cases produces enormous swelling, areas which feel boggy, a dusky red discoloration, and great burning pain. Gangrene of superficial areas is not unusual, due to thrombosis of vessels or coagulation necrosis from toxins. The discharges of the wound, if a wound exists, are apt to dry up, and the wound becomes foul, dry, and brown. The adjacent lymphatic glands are much enlarged. The disease is ushered in by a chill, which is followed by high oscillating temperature, due to suppurative fever, sapremia, or even septic infection or pyemia. Sweats are noted during falling temperature. Diffuse suppuration tends to arise in infected compound fractures, in extravasation of urine, and after the infliction of a wound upon a person broken down in health. It is not unusual after typhoid or scarlet fever, and is typical of phlegmonous erysipelas. The pus is sanious and offensive, and burrows widely in the subcutaneous tissue and intermuscular planes. This diffused suppuration may widely separate muscles and even lay bare the bones. It is a very grave condition, and may cause death by exhaustion, septic intoxication, septic infection, pyemia, or hemorrhage from a large vessel which has been corroded. *Cellulitis* of a mild degree is due to attenuated streptococci or to staphylococci. An area of cellulitis may surround an infected wound or a stitch-abscess. Its spread is manifested by red lines of lymphangitis running up to the adjacent lymphatic glands. Light cases may not suppurate, the lymphatics carrying off the poison. Any case of cellulitis is, however, a menace, and any severe case is highly dangerous (see Erysipelas).

Wooden or Ligneus Phlegmon.—This condition was fully described by Réclus in 1894. It is chronic inflammation of the cellular tissue and fascia of the neck. It is a very chronic condition beginning with hard swelling of one side or of the front of the neck and for weeks is unaccompanied by any other sign. The swelling may be at first localized, but it spreads slowly and widely and finally comes to involve an extensive area, even perhaps the front of the neck and both sides from the jaw to the collar-bone. It may involve the cervical muscles and thus create rigidity and it may compress the larynx and trachea and thus interfere with breathing. After weeks or perhaps a month or two the skin becomes edematous and red or rather of a violet hue. There is rarely pain and the significant facts are the gradually advancing hard swelling long unaccompanied by pain, discoloration, or cutaneous edema. The condition is due to the deposition and multiplication of pyogenic bacteria which reach the tissues from the lymph-glands and reach the glands from the mouth. Pus does not form at all or only minute encapsuled foci form because the bacteria are of

greatly attenuated virulence or because the local vital resistance is at a high level to these bacteria. Inflammation occurs, there is copious exudate and enormous amounts of fibrous tissue form.

Wooden phlegmon is occasionally found in syphilitics and is most apt to arise in those in poor health. It is frequently mistaken for sarcoma or carcinoma, in fact Lange believes it to be cancer. Wooden phlegmon is always dangerous and is frequently fatal.

Treatment.—Extirpation is not feasible and the surgeon instead makes numerous incisions and usually dresses with an antiseptic poultice. In these cases free suppuration occasionally occurs after a long delay and when it does occur a cure may promptly follow evacuation. If free suppuration were induced to occur by inoculations the effect might be favorable. In view of the difficulties, dangers, and great prolongation of these cases it is desirable that staphylococcic suppuration ensue upon the multiple incisions and it is justifiable to secure this by direct inoculation, or, better, by making multiple incisions and applying old-fashioned flaxseed poultices.

Acute Abscesses.—An acute abscess is a circumscribed cavity of new formation containing pus. We emphasize the fact that it is a *circumscribed cavity*—circumscribed by a mass of leukocytes and proliferating connective-tissue cells. A *purulent infiltration* is not circumscribed, hence it does not constitute an abscess. An essential part of the definition is the assertion that the pus is in a cavity of *new* formation, in an abnormal cavity; hence pus in a natural cavity (pleural, pericardial, synovial, or peritoneal) constitutes a *purulent effusion*, and not an abscess, unless it is encysted in these localities by walls formed of inflammatory tissue.

An acute abscess is due to the deposition and multiplication of pyogenic bacteria in the tissues or in inflammatory exudates. These bacteria attack exudates or tissues, form irritants which cause inflammation or intensify existing inflammation, and by exerting a peptonizing action on intercellular substance and the fibrin of the exudate liquefy tissue and the products of inflammation, and form pus. As a rule, within twenty-four hours after lodgment of the bacteria the exudation increases in amount, the migrated leukocytes gather in enormous numbers, the fibers of tissues swell, and the connective-tissue spaces distend with cells and fluid. The connective-tissue cells, acted on by pus cocci, multiply by karyokinesis, develop many nuclei, lose their stellate projections, degenerate, and constitute one form of pus-corpuscle, leukocytes forming the other. All the small vessels are choked with leukocytes, this blocking serving to cut off nourishment and tending to produce anemic necrosis. Liquefaction occurs at many foci of the inflammation, drops of pus being formed, the amount of each being progressively added to and many foci coalescing (Fig. 68). The pus-cavity is circumscribed, not by a secreting pyogenic membrane, but by a mass of fibroblasts, whose cells and intercellular material have not as yet broken down; such a mass of fibroblasts is often called embryonic tissue, and it is circumscribed by a zone of inflammation in which there are hordes of migrated leukocytes (Fig. 69). As an abscess increases in size, the embryonic tissue from within outward liquefies into pus, and the zone of inflammation beyond continually enlarges and forms more embryonic tissue. After a time the inflammation reaches the surface, the embryonic tissue glues the superficial to the deeper parts, the

superficial part inflames and becomes embryonic tissue, and the intercellular substance is liquefied. When pus has all but reached the surface, a thin layer of tissue only being undestroyed, an elevation or tit of thin tissue is formed, due to the fluid pressure. This process is known as *pointing*. The elevation or

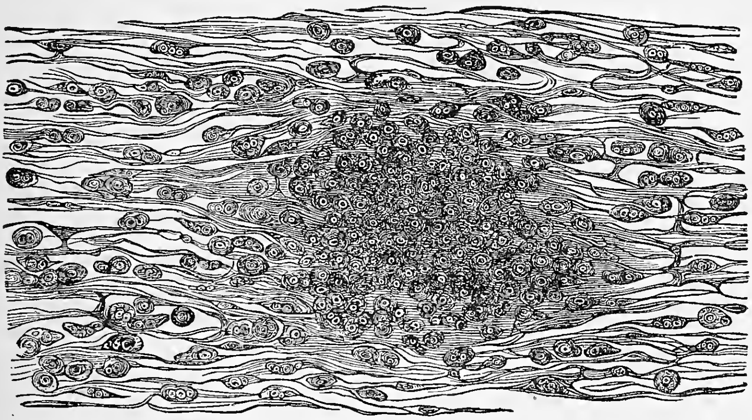


Fig. 68.—Infiltration of connective tissue of cutis (× 500) with beginning suppuration in the center (Senn).

point thins from tension and liquefaction, and finally gives way and *spontaneous evacuation* occurs. When an abscess forms in an internal organ or in some structure which is not loose, like connective tissue,—for instance, in a lymphatic gland,—a mass of pyogenic bacteria, floating in the blood or lymph, lodges, and these bacteria by means of irritant products cause coagulation necrosis of the adjacent tissue and inflammatory exudation around it. The area of coagulation necrosis becomes filled with white blood-cells, and the dry necrosed part is liquefied by the cocci. Suppuration in dense structures causes considerable masses of tissue to die and to be cast off, and these masses float in the pus. Death of a mass with dissolution of its elements is necrosis, or inflammatory gangrene. Pus travels in the line of least resistance. It may reach a free surface, or may break into a cavity or joint, may invade bone or destroy a vessel. When an abscess ceases to spread or is evacuated, the fibroblastic layer forming the walls becomes vascularized and is converted into *granulation tissue*. An abscess heals by the collapse of its walls and fusion of the granulations (union by third intention), or by granulation (union by second intention). In either case granulation tissue is ultimately converted into fibrous or scar tissue.

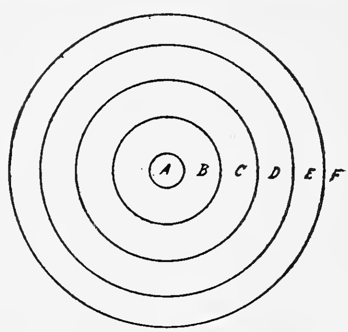


Fig. 69.—Diagram of an abscess: *A*, pus; *B*, layer of fibroblasts; *C*, tissue infiltrated with leukocytes; *D*, zone of stasis; *E*, zone of active hyperemia; *F*, healthy tissue.

Forms of Abscesses.—The following are the various forms of abscesses: *Acute*, which follows an acute inflammation. *Strumous, cold, lymphatic, tuberculous*, or *chronic* abscess is due to the bacilli of tuberculosis and does not contain true pus unless there is secondary pyogenic infection. It presents no signs of inflammation. A lymphatic abscess may form in a week or two, and hence is not necessarily chronic, which term is properly applied to a pyogenic infection of an infective granuloma. *Caseous* or *cheesy* abscess, a cavity containing thick cheesy masses, is due, perhaps to the fatty degeneration of inflammatory exudate and pus-corpuscles, but most commonly results from the caseation of a tuberculous focus. *Circumscribed* abscess is one limited by a layer of fibroblasts. *Diffused* abscess is an unlimited collection of pus, in reality not an abscess, but either a purulent effusion or a purulent infiltration. *Congestive, gravitative, wandering*, or *hypostatic* abscess is a collection of pus or tuberculous matter which travels from its formation-point and appears at some distant spot (as a psoas abscess). *Critical* or *consecutive* abscess is one which arises during an acute disease. *Diathetic* abscess finds its predisposing cause in a diathesis. *Embolic* abscess is due to an infected embolus. *Tympanitic* or *emphysematous* abscess is one which contains air or the gases of putrefaction. *Encysted* abscess, in which pus is circumscribed in a serous cavity. *Fecal* or *stercoraceous* abscess is one containing feces in consequence of a communication with the bowel. *Follicular* abscess is one arising in a follicle; *hematic* abscess, one arising around blood-clot, as a suppurating hematoma; *marginal* abscess, which appears upon the margin of the anus. *Pyemic* or *metastatic* abscess is the embolic abscess of pyemia. *Milk* abscess is an abscess of the breast in a nursing woman. *Ossifluent* abscess arises from diseased bone. *Psoas* abscess is a tuberculous abscess arising from vertebral caries, the matter following the psoas muscle, and usually pointing in the groin. A *sympathetic* abscess, arising some distance from the exciting cause, such as a suppurating bubo from chancroid, is not in reality sympathetic, because infective material has been carried from the primary focus. *Thecal* abscess is a purulent effusion in a tendon-sheath. *Tropical* abscess is an abscess of the liver, so named because it occurs chiefly in those dwelling in tropical countries: it usually follows dysentery; *urinary* abscess, caused by extravasated urine. A *verminous* abscess is one which contains intestinal worms and communicates with the bowel. A *syphilitic* abscess occurs in the bones during tertiary syphilis, and is gummatous and not pyogenic. *Brodie's* abscess is a chronic abscess of the bone, most common in the head of the tibia. A *superficial* abscess occurs above the deep fascia; a *deep* abscess occurs below the deep fascia. A *residual* or *Paget's* abscess is a recurrence of active changes, it may be after years, around the residue of a former tuberculous abscess.

Symptoms of Acute Abscess.—In an acute abscess, as before stated, a part becomes inflamed and a quantity of fibroblasts are formed; fibroblastic tissue is liquefied (as above noted) and pus is produced. An acute abscess can occur in a person of any constitution.

Local Symptoms.—Locally there is intensification of inflammatory signs and enormous increase of the swelling. At first the area is hard, but afterwards becomes soft, and it finally fluctuates. The discoloration becomes dusky. The pain becomes throbbing and the sense of tension increases. The pain is greater the more dense the implicated tissue and the greater

the number of nerves it contains. At every pulse-beat the tension in the abscess increases temporarily, and hence the pain momentarily increases. Pain is increased by a dependent position of the part. There is great tenderness. The pain may be felt at the seat of suppuration or may be referred to some distant point. Tenderness is located at the focus of disease. The cutaneous surface, if the abscess is adjacent, is seen to be polished and edematous, and after a time pointing is observed and fluctuation can be detected. If pus is deeply situated the skin may not be reddened and perhaps the area of induration cannot be palpated. In such a case there is often rigidity of the muscles overlying the abscess (as in abdominal suppurations), the skin may be edematous (as in some cases of empyema), and besides local pain there may be pain due to pressure upon a nerve trunk, the pain perhaps being referred to a distant point.

Constitutional Symptoms.—If there is a small collection of pus in an unimportant structure there may be no obvious constitutional disturbance. If the abscess contains much pus or affects an important part, disturbances generally appear, from slight rigors or moderate fever to chills, high temperature, and drenching sweats. The constitutional condition typical of an abscess is due to the absorption of retained toxins, and is known as "suppurative fever." When an abscess is open but ill-drained, or when it is unopened and deep-seated, long-continued suppuration causes a fever which is markedly periodic: the temperature rises in the evening, attaining its highest point usually between 4 and 8 P. M., and sinks to normal or nearly normal in the early morning (from 4 to 8 A. M.). When the temperature begins to fall, profuse perspiration takes place. This fever is known as *hectic*. Prolonged suppuration causes albuminoid changes in various organs, notably in the liver, spleen, and kidneys. Albuminoid changes are especially common when there has been mixed infection of a tuberculous area and long-continued suppuration. It also occurs as a result of syphilis.

Dr. J. C. DaCosta, Jr., tells us ("Clinical Hematology") that "in both trivial and extensive pus foci the number of leukocytes may be normal or even subnormal; in the former instance because systemic reaction is not provoked, and in the latter because it is overpowered. Leukocytosis may also be absent in case toxic absorption is impossible, owing to the complete walling off of the abscess. In all other instances save these, a definite and usually well-marked leukocytosis occurs, amounting on the average to a count of about twice the mean normal standard, but frequently greatly exceeding this figure in the individual case."

The signs and symptoms of an abscess are somewhat modified by location, and it is wise to discuss acute abscesses in different situations.

Acute Abscesses in Various Regions.—*Abscess of the brain* may follow cerebral concussion or fracture of the skull may arise during a general infection but in about 50 per cent. of cases results from chronic suppurative disease of the middle ear. In *abscess* of a silent region of the *brain* symptoms may long be entirely absent. The usual symptoms are a temporary initial rise of temperature which soon gives place to a normal and in one-half of the cases to a subnormal temperature, headache, vomiting, delirium, drowsiness, and choked disk. Localizing symptoms, spasmodic or paralytic, may be present. There is usually leukocytosis. In but few cases are there elevated tempera-

ture and sweats. Toward the end of the case there may be elevated temperature and delirium. In extradural abscess there is fever from beginning to end (page 720).

Appendiceal or *appendicular abscess* results from inflammation, usually but not always with perforation of the vermiform appendix, plastic peritonitis leading to agglutination of the mesentery and omentum, adhesion of the bowels and mesentery, and the formation of a barrier of leukocytes and a mass of fibroblasts. This process circumscribes the pus. If the pus in suppurative appendicitis has been formed by colon bacilli or staphylococci, it will probably be circumscribed and limited. If the pus has been formed by streptococci, it will probably not be limited, and the peritoneum will be attacked by diffuse septic peritonitis. The signs of appendicular abscess are pain, tenderness, muscular rigidity, the existence of a mass, which may be palpated through the abdominal wall or rectum and which is dull on percussion, vomiting, sometimes constipation, and sometimes diarrhea. Very seldom is there skin edema and fluctuation. The patient lies upon his back, usually with one or both thighs flexed. In appendicular abscess there is fever, usually higher at night than in the morning, profuse sweating occurring during the fall. In some cases the temperature is peristently high. In some the elevation is trivial. In some chills occur. A sudden fall of temperature with shock is produced by rupture of the abscess-wall. If this accident happens, general peritonitis quickly arises. In appendicular abscess there is marked leukocytosis unless the walls are very thick or unless the process has diffused and general peritonitis has taken place, in which conditions it may be absent. Appendiceal abscess may be assumed to exist when the symptoms of appendicitis persist after the fifth or sixth day, or when, after the symptoms have subsided, they reappear a day or two later (page 853).

Abscess of the liver may not be announced by symptoms until rupture. It may follow dysentery, may be a result of the lodgment of infected clots from the hemorrhoidal veins, may follow upon the infective phlebitis of appendicitis, may result from septic cholangitis or suppuration of a hydatid cyst. We usually find fever of an intermittent type, profuse sweats, pain in the back, the right shoulder, or the right hypochondriac region, enlargement of the area of liver-dulness, also hepatic tenderness, and finally constitutional symptoms of the existence of pus. Sometimes there are fluctuation and skin edema over the liver, and the general cutaneous surface may be a little jaundiced. The symptoms vary as the pus invades adjacent organs. When there are pain on respiration and evidences of diaphragmatic pleuritis the pus is probably breaking into the pleural sac. There may or may not be leukocytosis (see page 877).

Deep Abscess of the Neck.—The majority of these abscesses are due to suppuration of lymph glands, bacteria having reached the glands from an adjacent area of infection, cutaneous, mucous, or osseous. Suppuration beneath the deep fascia induces great pain and extensive swelling and often interference with respiration. The constitutional evidences of suppuration are noted. Acute suppuration under the deep fascia of the submaxillary region causes extensive inflammatory edema, interference with respiration and deglutition, violent constitutional symptoms, and often sloughing of tissues (see Ludwig's "Angina"). A deep abscess over the carotid artery is lifted

by each arterial beat and may be mistaken for aneurysm, but the pulsation is not expansible. The pus of a deep cervical abscess may track its way into the mediastinum or axilla or the abscess may break into a large blood-vessel, the pharynx, the wind-pipe or the gullet.

Axillary Abscess.—Superficial abscesses are usually multiple, are in reality furuncles, and result from infection of the sweat glands and hair follicles.

Deep abscesses are in most instances due to suppuration of the axillary lymph-glands. The most common cause is an infected wound or a focus of suppuration about the hand, forearm, arm or chest. An axillary abscess may result from caries of a rib or may follow a deep cervical abscess. An axillary abscess may be lifted at each beat of the artery and to this extent it resembles an aneurysm, but the pulsation is not expansile.

Acute retropharyngeal abscess is due to pyogenic infection of the retropharyngeal tissues. The abscess usually forms upon one of the lateral halves of the pharynx. It may be due to traumatism, to acute infectious diseases, to infective processes of the mucous membrane of the mouth, ear, and nasopharynx, or to pyogenic infection of a tuberculous abscess. In the great majority of cases the disease is due to suppuration of the deep cervical glands. There is pain, difficulty in swallowing, dyspnea, nasal voice, bulging into the pharynx, which is detected by inspection and palpation, enlargement of the deep cervical glands, fever, sweats, and great weakness. Tuberculous retropharyngeal abscess is considered on page 151.

Subphrenic or *subdiaphragmatic abscess* is apt to begin beneath the diaphragm, though in some few instances the pus forms above this muscle, and subsequently gains access to the region beneath. Such an abscess may contain not only pus, but gas, and in some cases also fluid from the stomach or intestine. The gas of a subphrenic abscess may have entered from a perforation of a hollow viscus or may have been made by gas-forming bacteria. Subphrenic abscess may arise after perforation of the bowel or stomach, or it may result from Pott's disease, perinephric abscess, traumatism, abscess of liver, kidney, spleen, or pancreas, empyema or pneumonia (Greig Smith). The symptoms are pain, fever, sweats, dyspnea, cough, and the physical signs of a collection of fluid beneath the diaphragm and often of gas in the cavity of the abscess. As in any other abscess there may or may not be leukocytosis (page 135).

Abscess of the lung gives the physical signs of a cavity; the expectoration is offensive and contains fragments of lung-tissue. An abscess may occasionally be located by the use of the *x*-rays. Pyemic abscesses may exist and yet escape discovery. (See Surgery of Respiratory Organs.)

Abscess of the mediastinum may arise secondary to deep abscess of the neck or vertebral suppuration; suppuration of the mediastinal glands, lung or pleura; caries of a rib or of the sternum, ulceration of the esophagus or pericarditis. It causes throbbing retrosternal pain, pain in the back, chills, fever, sweats, irregular pulse, and often dyspnea. A lump may appear which pulsates and fluctuates, but the pulsation is not expansile.

Perinephric abscess usually causes tenderness and pain in the lumbar region or about the hip-joint, which pain runs down the thigh and is accompanied by retraction of the testicle. Induration, fluctuation, or edema of the skin may be observed in the lumbar region. The constitutional symptoms of suppuration usually exist (page 135).

Abscess or *empyema of the antrum of Highmore* is a collection of pus within the maxillary antrum. It results from inflammation of the jaws, the teeth or the mucous membrane of the nose. It causes pain, edematous swelling of the overlying soft parts, and crepitation on pressure upon the superior maxillary bone. Pus may escape from the nostril of the diseased side when the head is bent in the direction of the healthy side. A rhinoscopic examination discloses the fluid passing into the nares. The antrum on the side of the abscess cannot be transilluminated by an electric light in the mouth (Garel's sign). The constitutional symptoms of suppuration usually arise.

Alveolar abscess is suppurative dental periostitis due to diseased teeth. The simplest form is a *gum-boil*, a collection of pus between the gum and the bone "external to the root of the tooth which is the seat of inflammation" ("Dental Surgery," by Sewill). In more severe cases the suppuration begins within the tooth socket and the pus escapes around the neck of the tooth, a distinct and local abscess may be situated at the end of the root, absorption of bone having occurred, or a considerable cavity may form in the bone, the external maxillary plate being perforated. In the very severe cases the cheek is involved. An alveolar abscess may break through the gum into the mouth or it may break externally through the cheek. Alveolar abscess causes intense pulsatile pain, marked swelling of the gum and cheek, and sometimes very great edematous and dusky swelling of the face. A sinus may follow its evacuation. Dead bone may form.

Abscess of the larynx invariably causes laryngeal edema which obstructs respiration and puts life in jeopardy. Such an abscess is most apt to appear upon the oral surface of the epiglottis but may arise within the larynx. It induces violent cough, pain, interference with the voice, swallowing, and breathing, and the swelling can often be felt with a finger and can always be seen by the aid of a laryngoscope.

An *ischiorectal abscess* is situated in the areolar tissue of the ischiorectal fossa. The pyogenic organisms usually gain entrance to the lymphatics by way of an abrasion, fissure, or ulceration of the rectum or anus. A perforation made by a foreign body may inaugurate the condition. In rare cases bacteria reach the fossa in the blood-stream. The pain is severe and throbbing; there are great tenderness, redness and edema of skin, induration, and usually the constitutional symptoms of pus-formation. Fluctuation is a very late sign because of the density of the fascia.

Prostatic abscess may result from catheter infection, from infection of the bladder or urethra, or from traumatism, but the commonest cause is gonorrhea. There may be one abscess, several abscesses, or multiple abscesses. Pus may break into the rectum, the bladder, or the urethra or may break externally. A prostatic abscess is manifested by chills, fever, sweats, frequency of micturition, tenderness of the perineum and rectum, and agonizing pain, developing during an attack of acute prostitis. A finger in the rectum can palpate the swollen gland.

Abscess of the breast follows absorption of pyogenic bacteria from a fissure or abrasion of the nipple. Some surgeons maintain that the bacteria enter along the milk-ducts, while others assert that they gain entrance by the lymphatics. It is most common in nursing women. Its symptoms are swelling, tenderness, pulsatile pain, dusky discoloration, skin edema, fluctuation, and usually constitutional disorder. (See Mastitis.)

Orbital abscess is a diffuse suppuration due to cellulitis or a collection of pus due to caries or necrosis of the orbital wall, suppuration of the accessory nasal sinus, facial erysipelas, or dental caries. In severe orbital cellulitis the movements of the eye are limited, the lids are very red and edematous, the conjunctiva is red and swollen (chemosis), and, if the case is not promptly relieved, optic neuritis may arise and sloughing of the cornea occur.

Von Bezold's Abscess.—In this condition the pus of a suppurating mastoid process breaks through the mastoid near the tip and enters into the sheath of the digastric muscle or the sheath of the sternocleidomastoid. There exist extensive inflammatory swelling of the neck, a history of mastoid trouble, usually a lessened amount of pus from the ear, pain in the neck and constitutional symptoms. The condition suggests thrombosis of the lateral sinus, but the symptoms are not so violent and are not pyemic as they are in that disease.

Abscess of the Groin or Pyogenic Bubo.—Such an abscess may have mounted up from the pelvis, tracked forward from the sacro-iliac joint, or descended in the psoas sheath from the vertebræ, but in a very great majority of cases it is due to suppuration of the lymphatic glands. A bubo may be tuberculous, venereal or pyogenic. A pyogenic bubo results from an area of infection in the trajectory drained by the lymph-vessels of the inguinal or femoral glands. The glands involved may be superficial or deep. The symptoms are those ordinarily linked with suppuration. Occasionally the pulsations of the great vessels may lift the mass.

Abscess of the Popliteal Space.—This results from traumatism, mixed infection of a tuberculous or syphilitic area, suppuration of the contained lymph-glands of one of the adjacent bursæ or of the neighboring bone. In rare cases it arises as a result of suppuration of the sac of an aneurysm. The symptoms are severe pain, swelling, flexion of the knee, and edema of the leg. The pulsations of the popliteal artery may be transmitted to the abscess. These pulsations are not expansile, as in aneurysm. Pus may pass under the deep fascia up or down the extremity, or may break into the knee-joint.

Suppurative thecitis or *felon* is a form of diffuse suppuration. (See Felon.)

Palmar abscess is a purulent effusion (page 645).

Furuncle and carbuncle are discussed on pages 1056 and 1057.

Empyema is a purulent effusion into the pleural sac (page 773). It is technically an abscess if it becomes encapsuled.

Diagnosis.—The diagnosis of an abscess rests upon—(1) its history; (2) fluctuation; (3) pointing; (4) surface edema; (5) the use of the tubular exploring needle; and (6) leukocytosis.

Fluctuation is the sensation imparted to a finger held against a sac containing fluid when a wave is started in the fluid by striking the mass with a finger of the other hand. Fluctuation cannot be obtained if the amount of fluid is small. It should never be sought for across a limb, but rather along it, because a false sense of fluctuation can always be obtained across the muscles of the limb. *Pointing* and *surface edema* have been discussed.

A suspected abscess in a part containing large blood-vessels under no circumstance should be opened by a bistoury without knowing that the diagnosis is certainly correct. This knowledge is obtained in some cases by inserting a small aspirating needle and observing the nature of the fluid which exudes. This operation must be performed with aseptic care; otherwise, if there is no

abscess, infection may be inaugurated; if there is an abscess, mixed infection may occur. The older operators used a grooved exploring needle, but many able surgeons object to its use on the ground that when plunged into an infected area, pus bathes the track of penetration and may cause infection of other tissues and diffusion of the pyogenic process. The tubular exploring needle is the proper instrument.

An abscess which moves with the pulse because it rests upon an artery may be confounded with an aneurysm. The pulse movements of such an abscess are in one direction only; the abscess is lifted with each pulse-beat; but does not enlarge, and if a finger is laid upon either side of it the fingers will be lifted, but not separated. The pulse movements of an aneurysm are in all directions; they are expansile, the tumor grows larger, and the fingers will not only be lifted, but will also be separated. The small tubular exploring needle may be used in doubtful cases; if aseptic, it will do no harm even to an aneurysm. A rapidly growing, small-cell sarcoma feels not unlike an abscess, but the exploring needle discovers blood, and not pus. A cystic tumor is

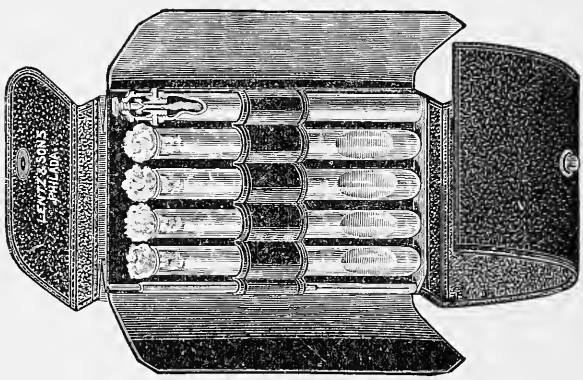


Fig. 70.—Vischer's case for carrying culture-tubes for inoculation.

separated from an abscess by the absence of inflammation, or, if it inflames, by the nature of the contained fluid. Ordinary caution will prevent one confounding an abscess with strangulated hernia. A tuberculous abscess is separated from an acute abscess by the absence of inflammatory signs in the former. The contents of the acute abscess differ from those of the tuberculous abscess. When an abscess exists in an important region (brain, appendix, liver, etc.), cultures of the pus should be taken after incision. Such studies often give valuable information as to the probable course of the condition, and an accumulation of many accurate observations will add greatly to scientific information. Fig. 70 shows a convenient case for carrying culture-tubes.

Prognosis.—The prognosis varies according to the number of abscesses, their location and size, the strength of the patient, and the virulence of the causative bacteria.

Treatment.—In the treatment of an abscess there is one absolute rule which knows no exception, namely, that whenever and wherever pus is found

the abscess should be evacuated at once, and, after evacuating it, thorough drainage must be provided for. It should be opened early, if possible even before fluctuation and positively before pointing, to prevent tissue destruction, sub-fascial burrowing, and general contamination. Drainage is continued until the discharge becomes scanty, thin, and seropurulent.

Alveolar abscess requires prompt incision through the gum, extraction of the diseased tooth in most cases, and the rinsing of the mouth at frequent intervals with hot fluid. Heat should not be applied externally, as it would favor external rupture. If spontaneous rupture externally is inevitable, then an incision must be made at the point where the abscess is nearest the surface. The cut will leave less scar than will spontaneous evacuation. It is sometimes necessary to gouge a line through the external table of the bone, pus being lodged within the two osseous plates.

Abscess of the liver, if the liver is adherent to the parietal peritoneum, is opened at one operation; if the liver is not adherent, the abscess is often operated upon in two stages. In the two-stage operation an incision is made along the edge of the ribs down to the liver, which organ is then stitched to the edges of the wound. In a day or two after the first operation the two layers of peritoneum are firmly adherent and the abscess can be opened without danger of the passage of pus into the peritoneal cavity. The abscess, located by an aspirating needle, is opened by the Paquelin cautery, is washed out with salt solution, and a tube is inserted. If care is taken the operation can be safely completed in one séance even if the liver is not adherent to the parietal peritoneum. If this course is determined on, after the liver is exposed by incision, the exposed surface of the organ is surrounded with iodoform gauze, the abscess is located by an aspirating needle, is opened by the cautery, is irrigated and drained as directed above. Some physicians try to locate an abscess by plunging an aspirating needle into the liver before making an incision. This procedure seems to me uncertain and dangerous.

Abscess of the dome of the liver may be reached by resecting a rib, incising the pleura, and opening through the diaphragm (transthoracic hepatotomy).

Abscess of the *mediastinum*, like all other abscesses, requires incision and drainage. This is effected, if the abscess can be reached from in front, by cutting between the rib cartilages or by trephining the sternum. Abscess of the posterior mediastinum can be reached only by resecting portions of several ribs near their vertebral ends.

In *abscess of the lung* an incision is made and the pleura is exposed. The incision is usually through an intercostal space; but if the spaces are narrow, it will be necessary to resect a rib. If the two layers of pleura are found adherent, the operation is proceeded with. If they are not adherent, they are stitched together with catgut sutures, and the surgeon waits forty-eight hours before continuing. This precaution is taken in order to prevent collapse of the lung from acute traumatic pneumothorax, during operation. The operation is completed by locating the pus by means of an aspirating needle, evacuating it by the cautery at a dull-red heat, and inserting a drainage-tube into the abscess-cavity.

A *subphrenic abscess* requires operation at once. Immediately before operating, if in doubt, it may be justifiable to endeavor to locate pus with an aspi-

rating needle. Incise the abscess and open any secondary abscesses. Many cases point below the diaphragm and are easily reached by an incision in the loin or in the epigastric region. Lannelonge resects the eleventh and twelfth ribs and raises the pleura out of the way. Some surgeons prefer to practice rib resection and incise the adherent pleural layers and the diaphragm. After drainage has been continued for a time it may be necessary to do a secondary operation in order to cure the lesion causative of the abscess, for instance, it may be necessary to close a gastric perforation.

In *abscess of the antrum of Highmore* bore a gimlet-hole through the superior maxillary bone, above the canine tooth, or perforate the bone by means of a trocar. Irrigate daily with boiled water or normal salt solution. Keep the opening from contracting by inserting a small tent of iodoform gauze. In persistent cases it may be necessary to draw a tooth, break through the socket of the first or second bicuspid into the antrum, and insert a silver or hard-rubber tube, and also to perforate the antrum from the inferior meatus and keep the opening patent. In very persistent cases osteoplastic resection of a portion of the upper jaw will be demanded.

In *appendicular abscess* incise, support the abscess-walls with gauze, remove the appendix in most cases, but not in all, and insert a drainage-tube and strands of gauze (page 864).

An *ischiorectal abscess* must be opened early. The surgeon never waits for fluctuation. Fluctuation is a very late symptom. To wait for it entails great destruction of tissue and serves no useful purpose. Place the patient on his side, with the legs drawn up. Insert a finger in the rectum, lift the abscess toward the surface, and incise it from the surface. The incision runs from the anal margin like a spoke from the hub of a wheel. Irrigate with salt solution, inject iodoform emulsion, insert a drainage-tube, dress, and let the patient know he is in danger of developing a fistula.

A *retropharyngeal abscess* must be opened early because delay may lead to fatal obstruction and because if spontaneous evacuation occurs the patient may be suffocated. Some surgeons open it from within the mouth, but this exposes the patient to the danger of septic bronchopneumonia from inhalation of purulent elements and to serious gastro-intestinal disorder from swallowing quantities of pus. Again, if opened through the mouth, the abscess is liable to become putrid. It is better to open it from the neck by Hilton's method, the incision being carried through the sternocleidomastoid muscle or posterior to it. Drainage is inserted and the abscess treated in the usual way.

In *abscess of the breast* make an incision radiating from the nipple, or, what is better, incise under the breast by means of a cut at the inferior thoracic mammary junction, and enter the abscess from beneath.

In *abscess of the brain* the skull should be trephined, the membranes incised, and the abscess sought for, opened, and drained (page 718).

In suppuration within the *orbit* due to cellulitis, incise from the conjunctiva and drain. In suppuration due to caries or necrosis of the upper orbital wall make a transverse incision through the upper lid, reach the pus by Hilton's method (page 144), remove carious or loose necrotic bone, and drain.

A *perinephric abscess* requires an incision in the lumbar region and free drainage.

An *abscess of the larynx* requires immediate scarification and inhalation of steam to abate swelling. In a severe case the surgeon should at once perform tracheotomy.

Bezold's abscess requires one or more incisions in the neck for drainage. Then the mastoid is exposed, its tip, including the osseous fistula, is removed, and its interior is cleared out by a complete operation.

A *prostatic abscess* should be opened promptly by a perineal incision.

In an ordinary *superficial abscess*, after cleansing the parts, make the skin tense, locate the superficial vessels and nerves, and plan the incision to avoid them. Incise with a sharp-pointed curved bistoury at the most dependent part of the abscess or through the region of pointing. If the abscess is upon the face or neck, make the incision in the line of the skin creases so as to limit the scar. The incision must not be made suddenly and fiercely, neither should it be made with hesitation and uncertainty. As Bryant says: "It should be done, as ought every other act of surgery, with confidence and decision, boldness and rapidity of action being governed by caution and made subservient to safety" (Bryant's "Practice of Surgery"). Permit the pus to run out spontaneously; pressure, as a rule, is undesirable because it may damage the abscess-wall and cause diffusion of the infection. If tissue shreds block the opening, they must be picked out with forceps. If the atmospheric pressure will not cause the pus to flow out, make light pressure with warm, moist, aseptic gauze pads. After the pus has come away gently wash the cavity with normal salt solution or boiled water, and drain with a tube for two or three days, when the discharge becomes serous. It is not desirable to overdistend the abscess-cavity with fluid, because the hydrostatic pressure might break down the wall of young cells and infection be diffused. Do not irrigate with powerful disinfectants. They cannot be used strong enough to really disinfect, but may easily be used strong enough to cause necrosis of an abscess-wall. Peroxid of hydrogen is not to be used unless the incision is large, because the gas it generates may tear the abscess-wall and diffuse the infection. Peroxid of hydrogen is a dangerous agent to inject into the cavity of a deep abscess of the neck, as the liberated gas may not escape from the opening, but may pass widely into the tissues and cause great distention. The author saw a child who narrowly escaped death after such an injection. In this patient the gas passed beneath the pharyngeal mucous membrane and the swelling almost occluded the air-passages. If an abscess contains putrid pus the incision should be free and after evacuation it should be irrigated with hot salt solution or peroxid of hydrogen and injected with iodoform emulsion. Pursue rigid antisepsis in dealing with purulent areas. It is true we already have infection with pyogenic bacteria, but infection can also take place with organisms of putrefaction, causing pus to become putrid, or with other bacteria, for instance those of tetanus. If a tube is not used and the cavity is packed with iodoform gauze, remember that gauze will not drain pus and requires to be changed once a day or oftener. An abscess should be dressed with hot, moist antiseptic dressings (antiseptic fomentation) and the part must be put at rest. When the discharge becomes thin and scanty, dry aseptic or antiseptic dressings are used.

In a *deep abscess* or an abscess situated near important vessels, do not boldly plunge in a knife. Hilton says to "plunge in a knife is not courageous,

as it is without danger to the surgeon, but may be fatal to the patient." Remember also that a large amount of pus displaces normal anatomical relations. *Hilton's method* of opening a deep abscess (as in the axilla or neck) is to cut to the deep fascia, nick the fascia with a knife, and then push into the abscess a grooved director until pus shows in the groove; along the groove push a pair of closed dressing forceps; after they reach the depths take out the director, open the forceps, and withdraw them while open, and so dilate the opening; then insert a tube and gently irrigate with warm salt solution.

Always endeavor to open an abscess at its most dependent part, remembering that the situation of this part may depend upon whether the patient is to be erect or recumbent. If we do not make the opening at the lowest point, all the pus will not run out and the walls will not completely collapse. A deep abscess must be drained thoroughly until the discharge becomes seropurulent. When the tube is removed it is wise to insert a tent of iodoform gauze just through the outlet of the abscess. This tent prevents the skin from closing over the channel. It is removed and a new one inserted every day until it is clear that there is no longer danger of fluid becoming blocked and retained. When an abscess contains diverticula or pouches they should be slit up or a counter-opening ought to be made. A counter-opening is made by entering the dressing forceps at the first incision, pushing them through the abscess to the point where we wish to make our counter-opening, opening the blades, and cutting between them from without inward. The blades are then closed and projected through the incision; they are opened in order to dilate the new door, and are closed again upon a drainage-tube, which is pulled through from opening to opening as the instrument is withdrawn. When pus burrows, insert a grooved director in each channel and slit the sinus with a knife. An abscess may make an opening through dense fascia, the opening being small like the neck of an hour-glass (*shirt-stud abscess*). Always examine to see if such a condition exists, and if it is found, incise the fascia.

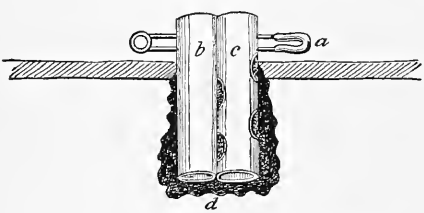


Fig. 71.—Drainage-tubes for abscess requiring irrigation.

In a deep abscess containing putrid pus, frequent irrigation is desirable. In such a case two tubes may be employed (Fig. 71). The tubes are prevented from slipping in by the use of a safety-pin (*a*). The irrigating fluid is passed into the cavity (*d*) through the tube *b*, which is without fenestra, and it runs out through the tube *c*, which possesses fenestra.

Rest is of the first importance in the healing of an abscess, and we try to obtain it by bandages, splints, and pressure, which will immobilize adjacent muscles and approximate the abscess-walls. If an abscess is slow to heal, use as a daily injection a solution of corrosive sublimate of the strength of 1 : 1000, or three drops of nitric acid to ℥j of water, or 3 grains of zinc sulphate to ℥j of water, or a 5 per cent. solution of carbolic acid, or a 2 per cent. aqueous solution of pyoktanin, or 20 drops of tincture of iodin to ℥j of water, or a very dilute solution of bichlorid of palladium. The constitutional treatment of an abscess depends upon the severity of the morbid process and the importance

of the structures involved. In a serious case the patient should be put to bed, opiates should be given with a free hand, the bowels be kept active by calomel and salines, skin activity be maintained, the taking of nutritious food insisted on, and stimulants liberally employed.

Purulent Effusions.—(See Suppurative Thecitis, Palmar Abscess, Suppurative Synovitis, Purulent Peritonitis, Empyema, etc.)

Tuberculous Abscess.—The tuberculous abscess is called, also, the *cold*, the *lymphatic*, the *congestive*, the *scrofulous*, the *strumous*, the *wandering*, or the *migrating abscess;* and it is very commonly called the *chronic abscess*. The Germans call it *Senkungsabscess*. Tuberculous abscess is the best designation, as this indicates the cause of the trouble.

The term cold abscess is often used, because the cutaneous surface over the disease is not warmer to the touch than is the skin of the corresponding part of the opposite side of the body. The term lymphatic abscess was employed because it was once thought that such abscesses arose only from lymphatic structures. Scrofulous abscess was the name given it when scrofula was supposed to be a definite disease, the common phase of which was this form of abscess. The term chronic abscess is employed because the condition usually develops slowly, and does not present the evidences of acute inflammation; an acute pyogenic abscess developing, as a rule, rapidly, and presenting positive signs of inflammation. I agree with the late Professor Ashhurst that the term chronic, in this connection, is improper; as it tends to give a wrong idea. It refers merely to time; and we know that an acute pyogenic abscess that is deep-seated may be rather slow in developing, and that a tuberculous abscess that is superficial may develop with considerable rapidity. When used properly, the term chronic abscess means that genuine pus exists, this pus having arisen from the pyogenic infection of the granulation-tissue of a lesion of syphilis, tuberculosis, or actinomycosis. In other words, a genuine chronic abscess is secondary pyogenic infection of an infective granuloma. The terms wandering, migrating, gravitating, and congestive have been used because the fluid products of a tuberculous inflammation are liable to wander a considerable distance away from the primary focus of disease. For instance, a tuberculous abscess that is discovered in the groin may have arisen from tuberculous caries of the vertebræ. This tendency to wander is not due to gravity, as one of the names of the condition would suggest; but the wandering always takes place in the line of least resistance.

It will be seen from the foregoing that a true tuberculous abscess is not an abscess at all, because it does not contain genuine pus. It is a collection of the degenerated products of tuberculous inflammation; and a tuberculous abscess may be defined as a circumscribed cavity of new formation, containing the degenerated products of a tuberculous inflammation. These products may have been formed in that region or may have passed to that point from some adjacent or distant focus of tuberculous disease. If a supposed tuberculous abscess is found to contain genuine pus, there must have been mixed infection with pyogenic bacteria; and such mixed infection either causes violent and dangerous inflammation or leads to the formation of a true chronic abscess, in which there is no sign of acute inflammation. The tubercle bacillus is not pyogenic. It can produce inflammation, but not pus, and pus can be formed in a tuberculous focus only by secondary infection with pus bacteria.

Situations of Tuberculous Abscesses.—These abscesses are particularly apt to form as the result of tuberculous disease of bones, joints, lymph-glands, and subcutaneous connective tissue; but the brain, any viscus, or any tissue in the body may present the condition.

Age.—No age is exempt, but children are most prone to the trouble; and the period of greatest liability is before the age of twenty years.

Contents.—The usual term for the contents is scrofulous, curdy, or caseous pus. As I said, it is not trus pus; but it resembles pus when viewed with the naked eye. Examination of this fluid by staining methods, by cultures, and by inoculations shows that it contains no pyogenic bacteria. It consists of liquefied and caseated tubercle; masses of coagulated fibrin; and bits of necrotic tissue. The tuberculous material is whitish, yellowish, or yellowish-green; thick; and without odor. Floating in this pus are portions of caseous matter, which, as the elder Gross said, resemble bits of soft boiled rice. Occasionally the tuberculous material, especially if it comes from disease of a lymph-gland or of a bone, is almost watery and nearly colorless, and contains curd-like masses, consisting of tuberculous granulations, coagulated fibrin, and necrotic tissue. It was previously stated that tuberculous pus is free from odor. This is not true of tuberculous pus of the ischiorectal fossa, which is highly putrid; but in an ischiorectal abscess, as a matter of fact, there is usually mixed infection with pyogenic organisms, as well as with the organisms of putrefaction. If tuberculous pus is permitted to stand, the curdy mass settles to the bottom, and a thin serous fluid remains above.

Formation of Tuberculous Abscess.—During their growth, the tubercle bacilli in the tissues cause a chronic inflammation. The cells of the tissues, especially the fixed cells, proliferate and form granulation tissue. This granulation tissue consists of multitudes of cell clusters, and each cluster is called a primitive tubercle (page 213). Each individual tubercle enlarges; myriads of new ones form; and many of the old ones fuse. These new cells, however, do not become vascularized. In the earliest stage of their formation, there are blood-channels; but these become closed through endothelial proliferation and through the pressure of cells external to them. The tuberculous area then becomes absolutely avascular. This avascular mass of cells is composed of what are known as epithelioid cells, and the cells obtain nourishment by imbibition. The nourishment is very incomplete. As the nodule enlarges, the nourishment grows more and more insufficient. Finally, the adjacent blood-vessels that furnished the fluid for imbibition become occluded, and nourishment is no longer possible. The toxins of the tubercle bacilli, acting upon this area of greatly lowered nutritional activity, produce coagulation necrosis; and caseation follows this. The caseation begins at many points near the middle of the tuberculous nodule. Each area of caseation enlarges. Several of them fuse, and eventually many caseated areas coalesce. The tuberculous lesion may be spreading at the periphery at the same time that it is undergoing caseation at the center. The bacilli in the caseated material soon die for want of nourishment. When an area of caseated tubercle is liquefied by the addition of serum, what we call caseous or curdy pus is produced; and the lesion is then known as a tuberculous abscess.

The Wall of the Abscess.—The wall of the abscess is formed by compressed or solidified tissues. In a very recent case the wall is soft and will readily

collapse. In an old case it is dense or actually fibrous and will not collapse. This wall of compressed tissue is not, as used to be thought, a pyogenic membrane, which secretes the tuberculous material; but it actually surrounds the tuberculous material and hinders its diffusion. As Roswell Park says, it is not a pyogenic membrane, but it is a prophylactic membrane. The inner surface of the wall of the compressed tissue is lined with tuberculous granulations, which at different points show different stages of the tuberculous lesion. This layer of tuberculous granulations is known as *Volkmann's membrane.* The fluid in the abscess may contain a few living bacteria, but often none can be found; and certainly the bacteria are not multiplying in this fluid, but they do multiply in Volkmann's membrane. When tuberculous matter has been long retained and thoroughly encapsulated the bacilli soon die for want of nourishment, and, because a culture from a supposed tuberculous area fails to show the bacilli of tuberculosis, we have not obtained conclusive evidence that the area is not tuberculous. We know this same fact to be true of the fluid of tuberculous empyema.

From the abscess-wall there may be one, two, several, or many sinuses tracking out. These sinuses are lines with granulation tissue exactly like the Volkmann's membrane in the main abscess; and they may spread by a sort of crawling progression for long distances, perhaps passing through dense fascia, and at their terminations form secondary tuberculous abscesses. The wall of an abscess may contain expansions or loculi. If an abscess spreads to some distant place, the tuberculous infection, of course, goes with it; and it is the tuberculous infection that causes the spread. The wandering of a tuberculous abscess is in the line of least resistance and is not the result of gravity. Injury, breaking, or contusion of this granulation tissue, if unaccompanied with the removal of all the tissue or the killing of all the germs it contains, may diffuse the pus and actually cause disseminated tuberculosis. We sometimes see such dissemination after spontaneous opening, non-aseptic operation, or forcible squeezing; and particularly after an imperfect operation that removes only a part of the tuberculous area.

Terminations of Tuberculous Abscess.—The abscess may slowly and gradually enlarge, and finally open of itself, either on the skin or on the mucous surface, or into some viscus or joint. It may become encapsulated by fibrous tissue, there being absorption of the fluid and shrinking of the entire focus, the caseous part perhaps remaining or becoming calcified. The tuberculous abscess may actually be replaced by fibrous tissue, and this constitutes a permanent cure. When the tuberculous area is merely encapsuled by fibrous tissue, some living bacilli may remain latent in the wall; and long afterwards, as the result of injury or of some other damage, an abscess may reform at the old site of disease. Sir James Paget calls this condition *residual abscess*, As a rule, the abscess, as it shrinks, tends toward cure. The bacilli usually die for want of material to nourish them; but occasionally they remain latent for a long period of time. When they do die, the tuberculous granulation tissue may become healthy tissue, be vascularized through the entrance of blood-vessels, and be converted into scar-tissue. Tuberculous abscess may also be cured by a surgical operation.

Secondary Infection of a Tuberculous Area with the Bacilli of Suppuration.—This is liable to occur when the abscess undergoes sponta-

neous evacuation, and may occur when it has been opened by the surgeon. It occasionally occurs when the abscess has neither undergone spontaneous evacuation nor has been opened by the surgeon, having been infected apparently as a point of least resistance. When such infection does occur, there is, in all probability, some area of ordinary suppuration elsewhere in the person's body; and the bacteria of suppuration have entered the body fluids. Pyogenic infection is apt to produce violent inflammation and profuse suppuration—a condition that is extremely dangerous, because septicemia is very liable to develop. In some very rare cases suppuration destroys the tuberculous area and cures the tuberculous disease. More commonly, however, it produces illness; and in large abscesses it may cause death. Because of this liability to secondary infection surgeons were long opposed to operating on tuberculous abscess unless it was evidently going to evacuate itself. In some cases, secondary infection produces a true chronic abscess (page 145). Infection with streptococci is much more dangerous than is infection with staphylococci. Acute inflammation with dangerous constitutional symptoms is particularly apt to arise: if the walls of the abscess contain very little tuberculous tissue, if they have been bruised or damaged with powerful chemicals; if there is poor drainage (and there is certain to be poor drainage if loculi exist, or when the incision is small and blocked with plugs of fibrin or necrotic tissue), if a partial or imperfect operation has been performed, if a number of virulent bacteria have been introduced, or if the vital resistance is at a low ebb.

Secondary Infection with the Bacteria of Putrefaction.—This complication is extremely grave and may produce death. It is commonly associated with pyogenic infection. The wound-fluid becomes intensely putrid, violent acute inflammation arises, and the absorption of materials from the wound induces the systemic condition known as sapremia or putrid intoxication.

Signs and Symptoms of Tuberculous Abscess.—A purely tuberculous abscess presents no evidence of inflammation, except swelling; and, owing to the absence of heat, it has received its name of cold abscess. The cutaneous surface looks and feels normal or is paler than normally, until the structures just beneath the skin or the skin itself become involved. When this happens, livid discoloration appears; but the lividity presents a very different appearance from the dusky discoloration of an acute abscess. Neither is the skin edematous or glossy as it is in acute abscess.

There is rarely tenderness in the region of the abscess, and still more rarely spontaneous pain. Pain and tenderness, although frequently absent in the area of a tuberculous abscess, may be complained of at the primary focus of disease. Tenderness is especially likely to be noted at the primary focus; and in cases of joint-tuberculosis and of bone-tuberculosis, it is nearly always present. There may or may not be pain at the primary focus, but there is frequently referred pain. For instance, in tuberculous disease of the hip-joint the pain may be referred to the inner side of the knee; and severe belly-ache is frequently observed in Pott's disease of the spine. At the point to which pain is referred, however, there is no tenderness. For instance, in the belly-ache, particularly of Pott's disease of the spine, the belly is not tender although the spine is. In sacroiliac tuberculosis the disease is often referred to the distribution of the sciatic nerve; but the nerve is seldom tender on pressure.

In a psoas abscess we find that pain in the spine can be induced by pressing on the spinous process of the diseased vertebra, by concussion to the heels or the head when the spine is held stiff, and especially by flexion of the spine; but the spinal pain is lessened or completely abolished by extension, fixation, and rest. The primary focus of disease, if spinal or articular, produces rigidity in the adjacent muscles; and rigidity obtains rest by inhibiting movement, but it also impairs the function of the part. In an intra-abdominal tuberculous abscess, there is rigidity of the abdominal muscles.

In a tuberculous abscess fluctuation is usually obtained readily because the fluid is not surrounded by a thick mass of granulation tissue and also because a considerable amount of fluid is usually present. A notable characteristic of a tuberculous abscess is the tendency to wander, and it may appear with suddenness at some distant point. Abscesses of the spine wander long distances, but the wandering is not the effect of gravity and is due to the disposition of the tuberculous matter to travel in the line of least resistance. The temperature of the body may be entirely normal if the infection is purely tuberculous. As a rule, however, there is a slight evening elevation; and the patient is weak and pale, grows tired readily, sleeps poorly, and has a wretched appetite and impaired digestion. The blood examination sometimes, but not often, shows a notable diminution in the number of red blood-cells; but the hemoglobin is usually lowered to 60 or 70 per cent. There is no leukocytosis. In multiple tuberculous foci, and particularly in tuberculosis in children, there is a marked decrease in the red blood-cells. If secondary infection occurs, there is a rapid and progressive diminution in the number of these cells and usually leukocytosis.

A tuberculous abscess underneath the deeper fascia may break through the fascia by way of a small opening, and a large secondary abscess may arise in the subcutaneous tissue. The entire abscess is thus shaped like an hourglass, the opening through the fascia being the narrowest point. Such an abscess is called a *shirt-stud abscess*. A tuberculous abscess is liable to form one, several, or many sinuses; and the end of each sinus may expand into a secondary abscess. The surgeon must always make a careful examination to try to determine whether the abscess is the primary disease-focus or whether the tuberculous matter has wandered from a distant point. He must also make a thorough examination to see whether anywhere in the body there are other regions of disease. He will often find such areas; for instance, in the lungs. In many cases, however, there is no clinical evidence that other areas exist.

The tuberculous abscess usually requires weeks or months to reach the overlying skin or mucous membrane and undergo spontaneous evacuation. That spontaneous evacuation is imminent is shown by livid discoloration and thinning of the skin. Finally, at the very thinnest point, a little tit is elevated. This condition is known as pointing and a rupture occurs at this point, tuberculous pus running out. Spontaneous evacuation is a peril, because it is liable to be followed by secondary pyogenic or putrefactive infection. After spontaneous evacuation has occurred, a true chronic abscess may form; but there may instead be violent acute inflammation, manifested by pain, heat, and dusky discoloration. If acute inflammation does arise, there develops a fever, which presents evening exacerbations and morning remissions, and is accompanied by an exhausting sweat during the night or early morning. Fatal septicemia or sapremia may follow spontaneous evacuation.

Results of a Tuberculous Abscess.—It may undergo spontaneous cure, and the cure may be lasting; but long after an apparent cure, a new abscess may form (the residual abscess of Sir James Paget). A tuberculous abscess may remain stationary for a very long time, and then perhaps diminish in size and be cured, or extend in size and rupture. After spontaneous rupture, suppuration may cure the tuberculous area by annihilating the tuberculous tissue; but, as a rule, after spontaneous rupture there is either an acute septic process or a chronic suppuration, constituting a genuine *chronic* abscess.

The pyogenic infection of a tuberculous area, if it induces long-lasting suppuration, may lead to the development of *albuminoid*, *amyloid*, *waxy* or *lardaceous disease* in the middle and inner coats of blood-vessels, in connective tissue, lymphatic glands, the membrana propria of mucous membranes, the heart, the liver, the spleen, and the kidneys. The victim of albuminoid disease is pale, greatly exhausted and emaciated, and very anemic; suffers with diarrhea and usually has capillary hemorrhages beneath the skin and mucous membranes. The albuminoid material can be detected chemically in the urine, if the kidneys are involved. Albuminoid degeneration is incurable, and is usually fatal; but if the patient is subjected to proper treatment soon after it begins it may be arrested and not progress. The amyloid material is deposited between the cells and not in them. The disease is apt to arise in chronic tuberculosis with secondary pyogenic infection, especially in bone tuberculosis, but it may arise in syphilis, chronic suppuration in non-tuberculous subjects, and chronic dysentery. The albuminoid substance resembles fibrin and there are many theories as to its source. One theory is that the condition is due to the flow of pus removing potash salts from the blood, and thus leaving a dealkalinized blood-serum.

Diagnosis.—The fluctuation, the absence of evidences of acute inflammation, the tendency to wander, and, in some cases, the sudden appearance, mark the diagnosis. The surgeon always examines with care to see whether there is some distant tuberculous focus from which the abscess may have wandered, or whether the abscess itself is at the primary seat of disease. The advancing impairment of the general health, the lessened amount of hemoglobin, the normal or almost normal temperature, and the absence of leukocytosis are points in the diagnosis of the condition. In a doubtful case the aseptic use of the tubular exploring needle is important, the fluid that emerges being studied with the microscope after staining, by cultures, and perhaps by inoculating it into guinea-pigs. The fluid that is withdrawn may contain no bacteria that can be demonstrated; but if it is sterile and there are no pyogenic organisms, one should strongly suspect tuberculosis.

Prognosis.—Advanced albuminoid degeneration gives a hopeless prognosis and any extent of albuminoid degeneration is unfavorable. Secondary pyogenic infection, as already stated, may produce death or a lingering suppuration. The prognosis is worse in very young children than in adults; and in any case it is unfavorable if the exhaustion deepens, if the anemia is marked, if there are tuberculous lesions in distant parts or in important organs or structures, if the patient is unable to take and digest food, and if the regions of tuberculosis cannot be extirpated or sterilized. Under other circumstances, the prognosis is favorable.

Tuberculous Abscesses in Various Regions.—Tuberculous abscess

of the head of a bone (see Brodie's abscess, page 434) arises in the cancellous structure of a long bone, most often in the head of the tibia, and is frequently noted as having been preceded by a trivial traumatism. The focus of tuberculosis seldom induces severe symptoms unless secondary pyogenic infection occurs (page 214). A tuberculous nodule forms as a result of tuberculous osteomyelitis. The bone about the nodule is hyperemic, the bony trabeculæ are thickened, and the cancellous spaces "are devoid of fat cells, and they contain a swollen semi-fibrous material" (Warren's "Surg. Pathol."). The center of the nodule becomes cheesy, the bone trabeculæ are absorbed and the bone becomes cheesy and broken up, the cheesy mass containing bone fragments. Finally the area becomes filled with tuberculous pus, the cavity which contains it being lined with tuberculous granulations. Distinct sequestra may form and the bone about the diseased focus undergoes sclerosis. In Brodie's abscess pain is continued but is not usually very severe, is of a boring character, and is worse when the patient is in bed. Attacks of synovitis arise from time to time in the adjacent joint. The bacteria of tuberculosis obtain access to the bone by means of the blood, and find in the bone a point of least resistance. There is no such thing as an acute abscess of bone. A pyogenic inflammation, of such severity that it would cause an acute abscess in soft parts, in bone causes acute necrosis.

Retropharyngeal or **postpharyngeal abscess** is often tuberculous. Such an abscess is usually due to caries of the cervical vertebræ, but can arise in the connective tissue of the parts or as a tuberculous adenitis. An abrasion of the mucous membrane may admit the bacilli to the connective tissue or the glands. A swelling projects from the posterior pharyngeal wall, and there is great interference with respiration and deglutition. Caseous matter from caries of the cervical vertebræ may reach the posterior mediastinum by following the esophagus, or may appear in front of or behind the sternomastoid muscle in the neck (Edmund Owen). A tuberculous abscess in this region is apt to undergo pyogenic infection, in which case the patient develops fever, sweats, pain, and prostration.

Dorsal Abscess.—The tuberculous matter in dorsal abscess arises from dorsal caries, flows into the posterior mediastinum, and reaches the surface by passing between the transverse processes. The tuberculous matter from dorsal caries may run forward between the intercostal muscles or between these muscles and the pleura, pointing in an intercostal space, at the side of the sternum, or by the rectus muscle. It may burst into the gullet, windpipe, bronchus, pleural sac, or pericardium. It may descend to the diaphragm and travel under the inner arcuate ligament to form a psoas abscess, or under the outer arcuate ligament to form a lumbar abscess. A psoas abscess points external to the femoral vessels, a characteristic which distinguishes it at once from a femoral hernia.

Iliac abscess arises from lumbar caries, the swelling lying in the iliac fossa and pointing above Poupart's ligament.

Psoas abscess is usually due to lumbar caries, but may arise from dorsal caries. The fluid usually points in Scarpa's triangle external to the femoral vessels, but may descend much lower (Fig. 72). A psoas or iliac abscess, by following the lumbosacral cord and great sciatic nerve, forms a gluteal abscess. These abscesses may open into the bowel, bladder, ureter, or peritoneal cavity.

Lumbar Abscess.—In a lumbar abscess the fluid produced by dorsal caries descends beneath the outer arcuate ligament, or the fluid from lumbar caries which collected anterior to or in the quadratus lumborum muscle passes between the last rib and iliac crest in the triangle of Petit, the small space bounded by the crest of the ilium, the posterior edge of the external oblique muscle, and the anterior edge of the latissimus dorsi muscle.*

Tuberculous abscess of the neck results from tuberculosis of the cervical glands. It is not often that such an abscess attains any considerable size. It tends strongly to spontaneous rupture, and, if this is permitted to occur, a livid, corrugated scar results.

Tuberculous abscesses of joints (see Chapter XIX).

Tuberculous Abscess of Rib.—It is not uncommon to find a tuberculous abscess of moderate size about a tuberculous rib. The pleura may become involved secondarily.

Tuberculous mediastinal abscess may result from the downward passage of a cervical abscess; from tuberculosis of the sternum, ribs, vertebræ or pleura, or from tuberculous mediastinal glands.

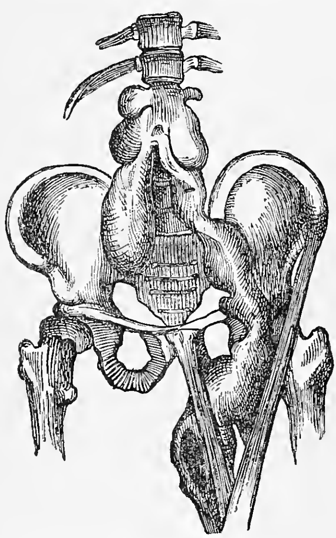


Fig. 72.—Psoas abscess (Albert).

Chronic abscess of the breast is a caseated and liquefied area of tuberculosis of the breast. A lump is detected, which slowly enlarges and finally ruptures, sinuses being formed. The axillary glands are apt to be implicated. The patient may belong to a tuberculous stock, as a rule gives a history of previous tuberculous troubles of various sorts, and has usually borne children. Chronic abscess of the breast causes little or no pain.

Treatment of Tuberculous Abscess.—For many years the majority of surgeons would not operate upon a tuberculous abscess unless it was on the point of rupturing. With the advent of antiseptic surgery, it was assumed that aseptic incision and drainage would be the proper treatment for these cases; but the results, except in small superficial tuberculous abscesses, have been extremely disappointing. If a large abscess is so treated, pyogenic infection will, in all probability, sooner or later occur, with all its possibilities of disaster. Incision and drainage is, therefore, restricted to small and superficial abscesses.

Treatment of Small Superficial Tuberculous Abscesses.—The surgeon must remember that after one has opened an apparently superficial abscess it is his duty to make an examination to see that there is no channel connecting the abscess with a deep or a distant focus. If he finds such a channel, he may be disposed to follow one of the plans of treatment outlined on pages 153 and 154. It is also his duty to see whether there are sinuses tracking off from the abscess;

*For a lucid description of these abscesses see Owen's "Manual of Anatomy," from which much of the above is condensed.

and if these exist, he must slit them up. If there are loculi in the wall of the abscess, he must stretch their mouths. He must be particularly careful to see that he is not dealing with a *shirt-stud abscess*, in which there is a little opening through the deep fascia connecting the abscess above with the abscess below. In a shirt-stud abscess the deep fascia must be freely incised. After the abscess has emptied itself, its walls must be thoroughly scraped with a curet, and the cavity must be drained with a tube or, preferably, packed with iodoform gauze. If the skin above a superficial abscess is diseased and discolored, and the abscess is on the eve of spontaneous rupture or has ruptured, the discolored skin must be cut away with scissors. If the discolored skin is allowed to remain, a livid and jagged scar will inevitably result. If it is cut away, a healthy scar, not very deforming, will result.

Treatment of Tuberculous Abscesses of Considerable Size.—*Method 1. Aspiration, Irrigation, and the Introduction of Iodoform.*—The operation is carried out with the most scrupulous aseptic care. The trocar is passed through the sound skin; is carried beneath the skin for an inch, as Senn suggests; and is then made to enter into the cavity of the abscess. The stylet is pulled out, and the flow of fluid is aided with very delicate pressure. Occasionally the tube will become blocked by necrosed tissue or plugs of fibrin. It is opened up again by pushing in a wire or forcing in a stream of sterile fluid. When tuberculous matter ceased to run out of the trocar, a very warm solution of boracic acid is thrown in in order to wash the abscess-walls. This can be inserted with a fountain syringe or with the special apparatus of Senn (Fig. 73). Enough of it is allowed to enter to over-distend the abscess-cavity, as Mr. Callender long ago advised. The fluid is then allowed to pass out; fresh fluid is passed in; and this procedure is repeated, perhaps again and again, until entirely clear fluid flows out. When this takes place, an emulsion of iodoform is thrown in by Senn's syringe. A ten per cent. emulsion in glycerin is as satisfactory as the more elaborate formulas. Verneuil used to employ iodoform and ether; but this is painful, is more liable to cause iodoform poisoning, and sometimes induces gaseous distention and ruptures the wall of the abscess. In order to prevent the danger of iodoform poisoning the surgeon should not introduce at one time more than eight drams of the emulsion, if dealing with an adult; or more than four drams, if dealing with a child. After the emulsion has been inserted into the abscess-cavity, the wound in the skin is sealed with a bit of gauze and iodoform collodion. Gauze is fluffed up and laid on the skin above the abscess, and the walls of the cavity are then forced toward each other by applying a roller bandage. The part is put at complete rest, and it is

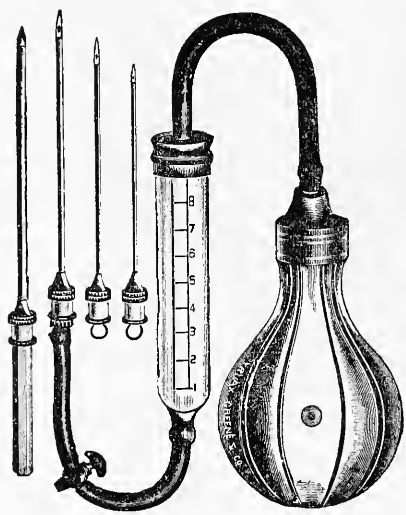


Fig. 73.—Senn's injection syringe.

usually necessary to put the patient in bed. Sometimes, although very seldom, one injection will produce a cure; but usually, after one or two weeks, it will be observed that the cavity has to some extent filled again. A second operation is then performed; and, if improvement is really taking place, it will be found that the fluid is not nearly so thin as it was at the first operation. It is needless to persist in this method after six or seven attempts have failed to cure. If the abscess has thick and uncollapsed walls, it is not fitted for treatment by aspiration and injection.

Method 2. Incision, Cleansing, and Suture.—If, owing to the considerable size or the rather rigid walls of the abscess, one believes that the aspiration method would be useless; or if the aspiration method has been tried and has failed, one may adopt the following plan. It should not, however, be employed, if the walls are very thick and rigid. An incision is made at the most dependent part of the abscess. The walls are scraped carefully with Barker's sharp-edged irrigating curet (Fig. 74), and are rubbed smooth with bits of

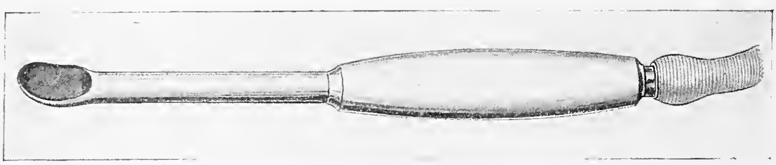


Fig. 74.—Barker's sharp-edged irrigating curet (Keen's Surgery).

gauze. The part is freely irrigated with hot boracic acid solution, and pressure is applied to arrest bleeding. Iodoform emulsion is introduced; the skin is sutured; dressings, compresses, and bandages are applied; and complete rest is secured. This operation may cure an abscess; or it may be necessary to repeat the procedure two or three weeks, or many weeks, afterward.

Method 3. Incision and Removal of the Primary Focus of Tuberculosis.—If one has not used the iodoform treatment, or if it has failed and if one finds that the primary seat of disease may be attacked and removed, an operation should be undertaken to get rid of Volkmann's membrane in the last-formed abscess and also to remove the primary tuberculous focus. An incision is made, when possible, that will lay open not only the last-formed abscess, but the primary lesion. Tuberculous tissue is thoroughly removed with Barker's spoon and by rubbing with gauze, or, perhaps, by scissors and forceps. Any focus of bone disease is curetted and touched with pure carbolic acid, and loose fragments of bone are removed. The part is irrigated with a hot solution of boracic acid; bleeding is arrested by pressure; and the wound is nearly, but not quite, closed, drainage being inserted at the most appropriate spot. Dressings, compresses, and bandages are then applied. In this operation, the entire tuberculous area has been removed, and the raw surfaces have been forced into contact; and there is no more danger of secondary pyogenic infection than there is in any ordinary wound.

General Treatment.—It is never to be lost sight of that in every case of tuberculous abscess the general treatment of tuberculosis must be rigorously pursued (see page 225). In the treatment of a cold abscess give nutritious

food, cod-liver oil, quinin, iron, and the mineral acids. Removal to the seaside is often indicated, life in the open air is imperative, and mechanical appliances may be needed for diseases of the bones and joints.

Chronic Abscess of Bone.—Make an incision to bare the bone. Open the abscess with the trephine, the gouge, or the chisel; curet interior of the wall of the cavity with a sharp spoon and rub it with bits of gauze; cut away the edges of the bone with rongeur forceps; irrigate the cavity with hot normal salt solution, dry its walls with gauze, and paint the cavity with pure carbolic acid; pack with iodoform gauze and apply antiseptic dressings. It is better not to employ an Esmarch apparatus. Bleeding will not be severe, and when no apparatus is used to prevent bleeding one can be sure that all the diseased bone has been removed, because sound bone bleeds and dead bone does not.

Cold Abscess of Lymphatic Glands.—In non-exposed portions of the body the capsule of the gland should be incised and dissected or scraped away and the cavity swabbed out with pure carbolic acid and packed with iodoform gauze. If the abscess is allowed to burst, it will cause an ugly scar; therefore in exposed portions of the body, as the neck, special effort should be made to prevent a scar by incising early before the skin is involved. When only a little caseated matter exists and the skin is not discolored, prepare the parts antiseptically, incise, rub the interior with gauze, inject iodoform emulsion, and suture the wound. It used to be a custom in such cases to carry a silk thread by means of a needle through the skin, through the gland, and out at its lowest point, the part being then dressed with gauze. In three days the thread was removed and a firm compress was applied. The plan is not satisfactory and incision is to be preferred. When the gland is almost entirely broken down and the skin above it is becoming purple and thin, insert a hypodermatic needle through sound skin into the abscess, draw off the fluid tuberculous matter, and inject iodoform emulsion. This procedure is to be repeated when the fluid again accumulates. By this means we can sometimes effect a cure in a week or so. When an abscess breaks or is on the point of breaking, cut away all purple skin, curet the abscess-walls (the abscess having become a tuberculous ulcer), remove the remains of gland and capsule, swab the cavity with pure carbolic acid, and dress with iodoform and antiseptic gauze.

Tuberculous glands ought to be extirpated before they caseate and form an abscess.

Tuberculous Abscess of a Rib.—This lesion requires incision of the soft parts and resection of the diseased bone. The tuberculous area is thoroughly curetted, rubbed with pure carbolic acid, and packed with iodoform gauze.

Tuberculous Mediastinal Abscess.—In tuberculous abscess of the mediastinum aspiration and injection of iodoform may prove efficient. In some cases it will be necessary to open and drain.

Cold Abscess of the Mammary Gland.—Many operators simply incise, curet, pack with iodoform gauze, and dress antiseptically. It is wiser to remove the entire gland, and to clear out the axilla, as in an operation for cancer, in order to prevent both recurrence and dissemination.

Large Cold Abscesses.—In view of the facts that these abscesses may

cause no trouble for years and that an operation may be fatal, some eminent surgeons are opposed to an operation unless the abscess is moving toward inevitable rupture or is disturbing the functions of organs by pressure. Most practitioners believe, however, and I agree with them, that this mass of tuberculous matter is a source of danger through being a depot of infective organisms which may overwhelm the system, and that death will seldom result from an operation performed by one who employs with intelligence strict antisepsis. In no other cases is attention to every detail more important, as a mixed infection may easily take place, and will probably mean death. As W. Watson Cheyne points out, over seventy per cent. of cases of spinal abscess treated by aseptic methods recover completely and without any real illness after such an operation. The recoveries from the old let-alone method will be infinitely less than this, and cases cured by operation usually remain well. The surgeon must always remember that the wall of the abscess and not the fluid in the cavity is the real seat of disease, and this wall must be actually removed or completely sterilized if operation is to be safe. To simply open, drain, and leave the wall to Nature to get rid of if she can is fraught with the gravest peril.

Psoas Abscess.—Some of these cases can be treated by aspiration and injection (page 153), others by incision and subsequent suture (page 154), others by the radical operation set forth on page 154.

Treves's operation for psoas abscess is described on page 618.

An operation occasionally performed for psoas abscess consists in an incision in the groin, an incision in the back, removal of carious vertebræ, thorough cleansing of the abscess-wall, and through-and-through tubular drainage. It has been found, however, that this operation is uncertain and dangerous. It is not advisable to remove carious vertebræ, and through-and-through tubular drainage is rarely used unless mixed infection already exists. When a large abscess breaks spontaneously, it should be widely opened at once, scraped and irrigated, rubbed with gauze, swabbed with pure carbolic acid, washed out with alcohol, and packed with iodoform gauze. If secondary pyogenic infection of a large tuberculous abscess does occur, the patient will develop septic fever and will probably die (*q. v.*).

Dorsal abscess and **lumbar abscess** are treated after the same plan as psoas abscess. One incision only is usually necessary unless the fluid has traveled to a distant point.

A **postpharyngeal abscess** must not be opened through the mouth. To open it in this manner puts the patient in danger of suffocation by fluid running into the larynx during or after the operation. Further, mixed infection of the abscess-area will be certain to ensue. Septic pneumonia will be apt to arise from inhaled infected particles, and profound gastro-intestinal disturbance will be liable to develop because of the inevitable swallowing of purulent, putrid, and tuberculous masses. Incise the neck and open into the abscess by Hilton's method, going through the sternocleidomastoid muscle or behind it. Rub the wall of the abscess with bits of gauze, remove any loose bone, irrigate with hot normal salt solution, inject iodoform emulsion, insert a tube or pack with iodoform gauze.

VII. ULCERATION AND FISTULA.

An **ulcer** is a loss of substance due to molecular death of a superficial structure. The molecular death is brought about by bacteria. Ordinary ulcers are caused by pus organisms. The action of the pus organisms is the same as in an abscess. A broken abscess becomes an ulcer, and an ulcer is in structure a half-section of an abscess. The floor of an ulcer consists of granulation tissue and corresponds with the abscess-wall. An abscess arises from molecular death within the tissues; an ulcer, from molecular death of a free surface. An ulcer may increase in size by molecular death of adjacent structures or by sloughing, that is to say, by death of visible masses of tissue. A wound healing by granulation is often wrongly called an ulcer. An ulcer must not be confounded with an excoriation. In an ulcer the corium is always, and the subcutaneous tissue is generally, destroyed, and a scar is left after healing. In an excoriation the mucous layer of epithelium is exposed, or this is destroyed and the corium is exposed. In an excoriation the corium is never destroyed, and no scar remains after healing. An ulcer heals by granulation (page 113). Embryonic tissue by vascularization becomes granulation tissue, granulation tissue is converted into fibrous tissue, the fibrous tissue contracts, and by pulling the edges of the ulcer toward each other lessens the size of the cavity. When the granulations reach the level of the skin the epithelium at the edges of the ulcer proliferates and the sore is soon covered over with new epithelium.

Necrosis of a superficial part may arise from—(1) Inflammation. The pressure of the exudate can cut off the circulation, or bacteria may directly destroy tissue. Suppuration occurs. (2) The action of pus bacteria, causing primary cell-necrosis. (3) Bacteria of putrefaction and organisms of suppuration acting upon a wound. (4) Traumatism or irritants, producing at once stasis, which is added to by secondary inflammation, the exudate undergoing purulent liquefaction. (5) Prolonged pressure. (6) Deficient blood-supply. (7) Faulty venous return. (8) Degeneration of a neoplastic infiltration (gummatous, malignant, or tuberculous). (9) Trophic disturbance. (10) Nutritional disturbances (as scurvy). Most ulcers are due to pus organisms, and even areas of necrosis that arise from something else (as gummatous degeneration) are likely to suppurate.

Classification.—Ulcers are classified into groups according to the condition of the ulcer and the associated constitutional state. In the first group we find the varicose, hemorrhagic, acute, chronic, irritable, neuralgic, etc. In the second group are placed the tuberculous, syphilitic, senile, scorbutic, etc. All ulcers, whatever their origin, are either *acute* or *chronic*, and such conditions as great pain, hemorrhage, edema, exuberant granulations, phagedena, sloughing, eczema, gout, syphilis, scurvy, etc., are to be looked upon as complications. The leg is so common a site of ulcers as to warrant a special description of ulcers of this part. In describing an ulcer state the patient's previous history; the supposed cause; the situation; the outline; the duration; and the mode of onset of the ulcer. State if the ulcer is single or if multiple sores exist, and if there is or is not pain. Whether or not any healing has ever occurred, and the patient's constitutional condition. Set forth the

complications; the state of anatomically related glands; the condition of the edge, the floor, and the parts about the ulcer, and the nature and quantity of the discharge.

Acute or **inflamed ulcer of the leg** may follow an acute inflammation and may be acute from the start, or may be first chronic and then become acute. It is especially common in drunkards, and among those of dilapidated constitutions. It is characterized by rapid progress and intense inflammation. There is rarely more than one ulcer. In outline these ulcers are usually oval, but may be irregular. The floor of an acute ulcer contains no granulations, but is composed of the raw and inflamed tissues, or is covered with a mass of gray aplastic lymph, or it may have upon it large greenish sloughs. The edges are thin and undermined. The discharge is very profuse and ichorous, excoriating the surrounding parts. The adjacent cutaneous surface is inflamed and edematous, and there is much burning pain. In some cases the glands in the groin enlarge. Constitutionally, there is gastro-intestinal derangement, but rarely fever. When the ulcer spreads with great rapidity and becomes deeper as well as larger in surface area, it is called "phagedenic." The formation of sloughs indicates that tissue death is going on so rapidly that the dead portions have not time to break down and be cast off. Limited stasis produces molecular death; more extensive stasis, a slough. If a chronic ulcer becomes acute, the granulations are destroyed.

Treatment.—In treating an acute ulcer of the leg, give a dose of blue mass or calomel, followed in eight or ten hours by a saline (ʒij each of Rochelle and Epsom salts), and order light diet. Deny stimulants except in a case of diphtheritic ulcer. Administer opium if pain is severe. Spray the ulcer with hydrogen peroxid, use the scissors and forceps to get rid of sloughs, and after sloughs are removed wash the ulcer with corrosive sublimate solution (1 : 1000), or paint it with pure carbolic acid. Paint the skin adjacent to the ulcer with equal parts of tincture of iodin and alcohol. Dress with hot antiseptic fomentations. Apply a bandage from the toes to well above the ulcer. Insist on the patient remaining in bed with the leg slightly elevated. Change the dressings before they become cool and always as soon as they are saturated with discharge. Every day paint the parts about the ulcer with equal parts of iodin and alcohol.

Many cases do very well after antiseptization, and dusting the ulcer with iodoform, lead-water and laudanum being applied to the inflamed parts around the ulcer; but in a bad case hot antiseptic fomentations, compression, and elevation are more useful until sloughs separate. If the discharge is offensive, apply acetanilid, aristol, or iodoform, or use gr. iij of chloral to ℥j of water, before applying hot fomentations or ordinary antiseptic dressings. A 25 per cent. ointment of ichthyol is very useful when applied to parts around the ulcer. If sloughs continue to form, touch the sloughing area with a 1 : 8 solution of acid nitrate of mercury or with a solution of pure carbolic acid, and reapply antiseptic fomentations. If an ulcer continues to spread, clean with peroxid of hydrogen, dry with absorbent cotton, touch with nitrate of mercury solution (1 : 8), and apply an antiseptic fomentation. Repeat application of nitrate of mercury every day until the ulcer ceases to extend and granulations begin to form. When granulations begin to form moist hot dressings are no longer necessary, and dry aseptic or antiseptic dressings can be used.

If an ulcer is covered with a great mass of aplastic lymph, touch daily with a solution of silver nitrate (gr. xl to ℥j) or with acid nitrate of mercury (1 : 15), and dress with iodoform and antiseptic fomentations. Give internally tonics, stimulants, and nutritious liquid food. In any case, when granulations form, dress antiseptically with dry dressings, or employ a non-irritant ointment, such as cosmolin. If granulations form slowly touch them every day with a solution of silver nitrate (gr. x to ℥j) and dress antiseptically, or apply a stimulating ointment (resin cerate or ʒj of ung. hydrarg. nitratis to ʒvij of ung. petrolii, or an ointment of copper sulphate, gr. iij to ℥j), or dress with gauze soaked in a solution of 3 drops of nitric acid to ℥j of gum Arabic.

Chronic ulcer of the leg is characterized by low action and slow progress. It may be chronic from the start, or it may result from acute ulcer. Usually it is found as a solitary ulcer two inches above the internal malleolus. *Syphilitic ulcers* often occur in a group, are usually crescentic, and are frequent upon the front of knee. A *tuberculous ulcer* may have no granulations, but is usually covered with pale edematous granulations, which signify the existence of a tendency to venous stasis. The edges of the tuberculous ulcer are undermined and irregular, the parts about it are livid and tender, and the discharge is thin and scanty (page 230). An *ordinary chronic ulcer* is circular or oval, and is surrounded by congested, discolored, and indurated skin, this induration being due to fibrous tissue, and there is often eczema or a brown pigmentation of the neighboring skin. The floor of the ulcer is uneven, and usually is covered with granulations, each of which is red and the size of a pin-point, but which may be exuberant or edematous. If granulations are absent, the ulcer has the appearance of a piece of liver, or is smooth and glazed. The edges are thick, turned out, and not sensitive to the touch. Occasionally, but rarely, they are thin and undermined. Some ulcers are indurated and adherent; this adhesion to the deeper structures prevents healing by antagonizing contraction. An ulcer may fail to heal because of severe infection; because of want of rest; because of absence of granulations resulting from deficient blood-supply; because of edematous granulations; because of exuberant granulations; because of adhesion to deep structures, or because of some constitutional disease.

Treatment.—In treating a chronic ulcer, give a saline cathartic every day or so. Treat any existing diathesis. Insist on rest and, if possible, elevation. Asepticize the ulcer. Draw blood by shallow scarifications of the bottom and edges of the ulcer and the skin about it. If the ulcer is adherent to deeper structures, make incisions like those shown in Fig. 75, each cut going through the deep fascia. These incisions, besides permitting contraction, allow granulation to sprout in the cuts and absorb exudate. Nussbaum advocated encircling the ulcer with an incision about one-half or two-thirds of an inch away from the edge of the ulcer, the incision passing through the skin. After incision keep the part elevated and dressed antiseptically for two days. In two days after scarification or incision scrape the ulcer with a curet until sound tissue is reached.

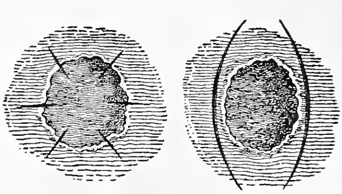


Fig. 75.—Incisions for adherent ulcer.

Use hot antiseptic fomentations for two days more, then paint the parts adjacent to the ulcer with tincture of iodin and alcohol (1 : 3), dress the parts about the ulcer with ichthyol ointment, and dress the ulcer antisepically or with sterile gauze. In a day or so the use of ichthyol can be discontinued and the ulcer can be dressed with sterile gauze, normal salt solution, boric acid, bichlorid of palladium, chlorin-water, a solution of permanganate of potassium, sulphur, glutol, protonuclein, or bovinin. Glutol (formalin-gelatin) is very useful in some cases and so is protonuclein. When healing begins, treat as outlined for healing acute ulcer (page 158).

Unna's dressing is satisfactory in many cases. It is applied as a fluid, painted on when hot. It solidifies on cooling and resembles rubber. The paint is made as follows: Dissolve 4 parts of the best gelatin in 10 parts of water by means of a hot-water bath. While the fluid is hot add 10 parts of glycerin, and then 4 parts of powdered white oxid of zinc and stir energetically until the mixture is cold. Melt the paint before using by placing the receptacle in a hot-water bath. The extremity must be clean and thoroughly dry. Apply the paint from just above the roots of the toes to just below the knee. Cover the layer of paint with a gauze bandage; put over this another layer of paint, then another bandage, and so on until three, four, or five bandages have been applied. To prevent wrinkling, put the bandages on in pieces. The outer layer of the dressing is a coat of the paint. This dressing is worn from four to eight weeks unless it loosens sooner. When it loosens, it is changed. If the ulcer discharges freely and stains the dressing, cut a trap-door in the dressing and through this cleanse the ulcer and apply dressings and a bandage as often as necessary (Michel, in "Chicago Clinic," No. 8, 1900).

An excellent treatment if the patient must walk about is *camphor*, first recommended by Schulze ("Münchener medicinische Wochenschrift," March 19, 1901). It is most conveniently used, as Walbaum shows, in the form of spirits of camphor ("Münchener medicinische Wochenschrift," June 25, 1901). He applies the dressing in the following manner: Clean the ulcer with green soap and dress it daily with dressings wet with a 2 per cent. solution of the acetate of aluminium. In about three days the discharge will become scanty and free from odor. It is at this period that camphor should be used. A small piece of gauze wet with spirits of camphor is applied directly and only to the ulcer. Over this is applied a large piece of dry sterile gauze, a rubber dam, a large piece of absorbent cotton, and a bandage from the toes up. Every other day the dressings are removed, the ulcer is washed with a 2 per cent. solution of carbolic acid, and the dressings are reapplied. Usually the ulcer is healed in three weeks.

Complications.—Remove by scissors and forceps any badly damaged tissue. Take out dead bone; slit sinuses; trim overhanging edges. Treat **eczema** locally by washing with ethereal soap and applying powdered oxid of zinc or borated talcum, the leg then being wrapped in cotton. Unna's paint is very useful in chronic eczema. If the part is crusted, the crusts should be removed by applying some oily materials and washing with ethereal soap and water. Ordinary soap should not be used. In an acute case soap and water always do harm and the part is to be cleaned by "gently wiping with cold cream or petrolatum" (Stelwagon, on "Diseases of the Skin"). If crusting is very marked it may be necessary to remove it by means of an ordi-

nary poultice, or, better, a starch poultice made with a 2 per cent. solution of boracic acid. When scales or crusts are slight or absent or when they have been removed, the remedial agent should be applied. The remedies for eczema are legion. Among them are a solution of lead acetate; lead-water and laudanum; a powder composed of 30 grains of powdered boracic acid and ½ ounce each of talc and zinc oxid; ung. picis liquidæ, ʒj, with sufficient ung. zinci oxidi to make ℥j; ½ ounce of liquor carbonis detergens to 1 pint of water. In every case of eczema place the patient upon a plain and nutritious diet; order him to avoid wines and liquors; give an occasional saline laxative; keep the skin and kidneys active, and if the patient is gouty or rheumatic, give appropriate remedies. The value of arsenic in eczema has been much overrated.

Varicose veins demand either ligation at several points, excision, Trendelenburg's operation (page 396), circumcision by Schede's method (page 397), or the continued use of a flannel roller or a Martin rubber bandage. Never operate on varicose veins if phlebitis exists, unless a clot has formed, in which case apply a ligature above the clot. *Inflammation* is met by rest, elevation, painting the neighboring parts with dilute tincture of iodin, and applying about the ulcer ichthyol ointment. For *calloused edges*, blister, employ radiating incisions, or cut the edges away. Ordinary *thick edges* should be strapped. In strapping use zinc oxid adhesive plaster and do not completely encircle the limb (Fig. 76). When the parts are *adherent* the ulcer is immovable, being firmly anchored to structures beneath it. In such a condition completely or partly surround the sore with a cut through the deep fascia (Fig. 75). This cut sets the ulcer free from its anchorage and permits it to contract. *Edematous granulations* require dry dressings and pressure by a flannel bandage, a rubber bandage, or adhesive plaster. If the bottom of the ulcer is *foul*, dry it and touch with a solution of acid nitrate of mercury (1 : 8) or with crystals of pure carbolic acid. Repeat this every third day and dress with hot antiseptic fomentations until granulations appear. *Superfluous granulations* (proud flesh) should be cut away with scissors, scraped away, or burned down with a strong solution of silver nitrate, with the solid stick of lunar caustic, or, better, with pure carbolic acid which cause much less pain than does silver. *Absence of granulations* or scantiness of granula-

Fig. 76.—Strapping an ulcer of leg (Keen's Surgery).

tions means deficiency of blood-supply. The surgeon endeavors to bring more blood to the part, and to do this induces inflammation. The usual method of procedure is to apply daily to the sore a solution of nitrate of silver (10 or 15 grains to the ounce). Argyrol of a strength of 25 per cent. is not painful and is as efficient. In obstinate cases blister the ulcer or scrape it, or paint it with tincture of iodin, or apply pure carbolic acid, or touch it with the actual cautery.

Irritable ulcer is due to exposure of a nerve and destruction of its sheath (page 163). Find with a probe the painful point and incise it with a tenotome, or curet the ulcer or burn it with the solid stick of silver nitrate.

If healing entirely fails, *skin-graft.* Among the methods of skin-grafting are—(1) Reverdin's, (2) Thiersch's, and (3) Wolfe's. (See Plastic Surgery.)

When a man having an ulcer must go out and about, the camphor treatment can be employed (page 160), Unna's dressing may be applied (page 160), or the patient can use a firmly applied roller, or, better still, a Martin bandage. Martin's bandage, which is made of red rubber, limits the amount of arterial blood going to the ulcer and favors venous flow from the sore and its neighborhood. The bandage should be used as follows: Before getting out of bed spray the sore with hydrogen peroxid by means of an atomizer, remove the froth with absorbent cotton, wash the leg with soap and water, dry it with a towel, dust the skin with borated talcum powder, and apply the bandage. All of these things should be done before putting the foot to the floor. At night, after getting on the bed, remove the bandage, wash it with soap and water, dry it with a towel, hang it unrolled over the back of a chair to air, and again cleanse the leg and ulcer. If these rules are not strictly observed, the Martin bandage will produce pain, suppuration, and eczema of the leg.

Tuberculous Ulcers (see pages 229, 230).

Syphilitic Ulcers (see page 285).

A **healthy ulcer** is covered with small, bright-red granulations which do not bleed on touching, are painless, and grow rapidly. The edges of the sore are soft and show the opalescent blue line of proliferating epithelium. The sore is movable, the discharge is purulent and yellow, and the parts about are not inflamed.

Various Ulcers.—The **fungous** or **exuberant ulcer** is produced by interference with the return of venous blood from the part, and it is specially common after burns and other injuries when cicatricial contraction causes venous obstruction. The granulations are large, deep red in color, bleed when touched, form rapidly, and mount above the level of the skin. The discharge from a fungous ulcer is profuse, thin and bloody. In the treatment of such an ulcer venous return must be favored by bandaging and by elevation of the part. If the edges are very thick, divide them in a number of places. The superfluous granulations should be burnt down with lunar caustic or pure carbolic acid or should be cut off. Strapping with adhesive plaster or the use of a rubber bandage does good. The sore can be dressed with europhen, aristol, or dry aseptic gauze.

A **varicose ulcer** is an ulcer complicated by varicose veins. It is usually single, is oval, round, or irregular in outline, and is most often seen above the inner malleolus. Its edges are thick, everted, and swollen. The swelling is largely due to edema, and is found to pit on pressure. The edges are not

undermined, but slope gently to the floor of the ulcer. The floor is usually covered with rather large granulations which bleed freely on touching. In a varicose ulcer the destruction of tissue often begins at the margin of a congested area and advances toward the center. Such an ulcer is usually surrounded by eczema. To aid the healing of a varicose ulcer it is first of all necessary to favor the return of venous blood from the part by position and bandaging. Martin's bandage is very useful. It may be necessary to operate on the veins.

Erethistic, irritable, or **painful ulcers** are very sensitive, a condition due to the exposure of nerve-filaments and destruction of nerve-sheaths. Irritable ulcers are especially found near the ankle, over the tibia, in the anus (fissure), or in the matrix of the nail (ingrowing nail). Fissure of the anus is considered on page 1012. An *ingrowing nail* is sometimes encountered on the finger but far more commonly affects the toe. The great toe is especially apt to suffer. We call it ingrowing nail but the condition is really overgrowing skin. As a result of wearing ill-fitting boots or stockings, especially shoes which are too short or are pointed, the toes are forced together and the skin at the edge of the nail is pushed open. After a time an ulcer forms.

When a nail begins to ingrow the condition can usually be arrested by wearing well-fitting shoes and stockings, allowing the nail to grow somewhat long and cutting it square across instead of cutting away the troublesome corner. Daily a little absorbent cotton should be packed under the ingrowing corner. In more severe cases under local anesthesia, cut away the overlapping skin and a portion of the flesh on the side of the toe, split the nail longitudinally, remove the ingrown portion of nail and a corresponding part of the matrix.

An erethistic ulcer of the cutaneous surface is treated as follows: Curet and touch with pure carbolic acid or with the solid stick of silver nitrate. Chloral, gr. xx to the ounce, allays the pain; so do cocain and eucain for a time. In some cases the painful area can be located with a probe and the nerve-filament divided with a tenotome.

The **indolent ulcer** shows no tendency to heal. In such an ulcer there is usually venous congestion from varicose veins or from cardiac weakness. A great mass of scar-tissue forms at the base and edges, which fastens the ulcer to bone or fascia, so that the edges cannot contract. Healthy granulations cease to form. The edges of such an ulcer are thick, smooth, immovable, and free from tenderness. Granulations are entirely absent or there are seen here and there a few unhealthy granulations. The discharge is thin, seropurulent, and offensive. The parts about the ulcer are congested and pigmented. The pigmentation is due to the fact that in the area of chronic congestion numbers of red blood-cells have been disintegrated. Such an ulcer is treated by making incisions to loosen the base and edges, so that contraction can take place. Venous congestion is corrected by means of position, the use of compression, and in some cases the administration of cardiac stimulants. In all cases the surgeon employs stimulating applications to the ulcer in order to increase the supply of arterial blood.

The **callous ulcer** is the most chronic form of indolent ulcer and is sunken deeply below the level of the skin. Its border is hard and knobby. Its floor shows no granulations, and is either smooth and glistening or foul and liver-

colored. The discharge is thin and scanty, and the ulcer varies little in appearance from week to week or even from month to month. The treatment consists in scraping and cauterizing the ulcer; making radiating incisions through the margins and floor or elliptical incisions about the ulcer; applying antiseptic dressings and a firm bandage. In some cases the ulcer should be strapped. In severe cases it is necessary to extirpate the ulcer and apply skin-grafts.

Hemorrhagic ulcers bleed easily and profusely. Pressure must be applied; it is sometimes necessary to cut or burn away the granulations.

Phagedenic Ulcers.—The phagedenic ulcer results from the profound microbic infection of tissues debilitated by local or constitutional disease, and is commonly venereal. This ulcer has no granulations and is covered with sloughs; its edges are thin and undermined, and it spreads rapidly in all directions. Such an ulcer should be touched with strong caustics or Paquelin's cautery, and dressed with iodoform gauze and antiseptic fomentations. Tonics and stimulants should always be administered.

The **edematous ulcer** may result from impediment to the venous return or, as Nancrede points out, may be produced by the persistent use of poultices or wet dressings upon any ulcer.* It is most often met with in tuberculous processes and is occasionally seen when varicose veins exist. The granulations are large and pale, and are apt to bend over like unsupported vines. The discharge is profuse and seropurulent. The edges are softened and desquamating. An edematous ulcer requires dry dressings, stimulation, and compression.

A **rodent** or **Jacob's ulcer, noli me tangere,** or **cancroid ulcer,** is a superficial epithelioma developing usually from sebaceous glands, sweat-glands, or hair follicles. It requires scraping and cauterization, or, what is better, excision (page 334).

Marjolin's ulcer (Fig. 77) is an epithelioma arising from a chronic ulcer or an old cicatrix. The malignant change begins at some point of the edge of the ulcer, and its first evidence is induration. The induration spreads slowly and comes to involve a considerable part of or even the entire ulcer. Marjolin's ulcer is the seat of scalding, darting pain; the discharge is profuse, ichorous, and foul, and the floor of the ulcer is uneven, warty, or cauliflower-like. The anatomically related lymph-glands eventually become involved. This involvement is rarely early because induration has blocked lymph-channels. In order to confirm the diagnosis a bit of tissue should be removed and the removed piece must include a portion of the edge of the ulcer and of some apparently sound tissue beyond it. If a microscopical examination shows epithelial infiltration of the apparently sound tissue, a diagnosis of malignant disease must be made. In an early stage of such an ulcer free extirpation and removal of the anatomically related glands may cure the patient. In a more advanced case, if an extremity is involved, amputate and clear out the related lymphatic area. In a very advanced case use the *x*-rays.

Decubitus, or **bed-sore,** is due to pressure upon an area of feeble circulation (page 182). It is in most instances a condition of gangrene.

Neuroparalytic or **trophic ulcer,** is due to impairment of the trophic nerve-fibers or of the trophic centers in the cord.

* "Principles of Surgery."

The **perforating ulcer,** as it was named by Vesigne, is believed to result from peripheral neuritis. It is certain, however, that in some of these cases there is arterio-sclerosis and it has been held that the vascular sclerosis is the real cause and that the nerve changes are secondary to the vascular changes. My own belief is that perforating ulcer is a condition dependent upon both arteriosclerosis and peripheral neuritis, traumatism usually being the exciting cause of the ulcer. It is met with most frequently in diabetics, but may be encountered in the victims of chronic alcoholism, injuries and diseases of the spinal cord, injuries and diseases of nerves, Bright's disease, and syphilis. I have seen this ulcer in an individual with a fractured spine, in two tabetics, and in several diabetics. The perforating ulcer commonly affects the plantar surface of the metatarsophalangeal joint or the pulp of the great toe or little toe about a callosity or corn. It may arise on the heel or the sole or the side of the foot. It is usually unilateral but sometimes

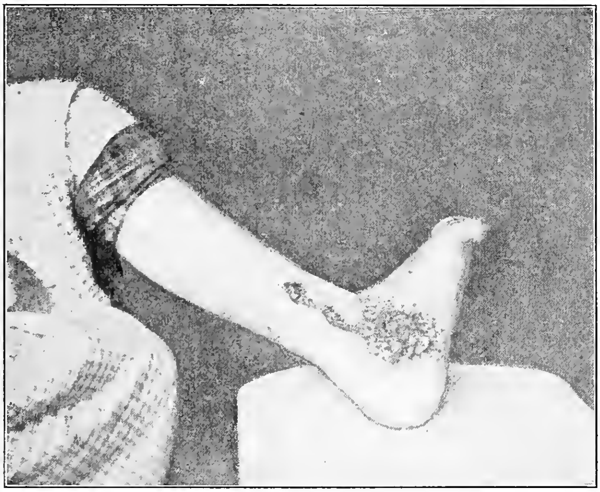


Fig. 77.—Marjolin's ulcer.

both feet are affected. Very rarely it affects the palm of the hand. The parts about the corn inflame, and pus forms and reaches into the bone. A sinus evacuates the pus by the side of the corn or callosity or the center of the callosity exhibits a blister containing sero-pus. A portion of the callous mass is cast off and a shallow ulcer is often exposed. This ulcer is small, has a punched-out appearance, and is surrounded by calloused margins. The ulcer penetrates deeply and after a time the bone is laid bare or the joint opened. The margins of the ulcer or sinus exhibit sprouting granulations and these are encircled by an area of markedly thickened epidermis. In very rare cases more than one ulcer is present on the foot. The discharge from a perforating ulcer is thin and scanty and the ulcer, which slowly advances, is very chronic. It is not painful and is slightly, if at all, tender. The foot is cold and often edematous and the parts about the ulcer may be anesthetic. The ulcer may heal when the patient is kept in bed and open again when he gets about. The disease is far more common among

males than among females and is most often met with in the fourth or fifth decades of life. As this ulcer may be present in anesthetic leprosy, in diabetes, peripheral neuritis, syphilis, in a paralyzed limb, and tabes dorsalis, and as the part on which it occurs is apt to be sweaty, cold, and more or less anesthetic, and as the sore may be hereditary, it is usually set down as trophic in origin. In treatment of a perforating ulcer I follow the plan suggested by Treves. This consists in putting the patient to bed and applying poultices to the sore. Every time a poultice is removed the raised epithelium around the ulcer is cut away and then the poultice is reapplied. In about two weeks an ulcer remains surrounded by healthy tissue. Treves treats this sore with glycerin made to a creamy consistency with salicylic acid, to each ounce of which mixture ♏x of carbolic acid have been added. He directs the patient to wear during the rest of his life some form of bunion-plaster to keep off pressure. If in a perforating ulcer the bone is diseased, it must be removed. If the patient is diabetic he must be placed on antidiabetic diet and drugs. Nerve-stretching has been recommended as the proper treatment for perforating ulcer, but I have never tried it. No matter what treatment is employed, the sore is apt to reappear in the old situation or an adjacent region, when the part is subjected to pressure. In order to prevent pressure upon the region of ulceration some advise the use of an artificial leg, the knee being kept bent. It may be necessary to amputate the toe or the foot.

The **scorbutic ulcer** is covered with a dark-brown crust, beneath which are pale and bleeding granulations. The parts adjacent are of a violet color.

Epitheliomatous, sarcomatous, tuberculous, and syphilitic ulcers and ulcers of the stomach and duodenum are considered under these respective diseases.

Curling's Ulcer.—This is an ulcer of the first portion of the duodenum which in rare cases follows an extensive burn of the cutaneous surface. It is small, clean cut, and deep and is due to embolism, the emboli being hyaline material precipitated from the blood. The treatment is gastroenterostomy. If perforation occurs the treatment is as for any other perforating duodenal ulcer.

Fistula.—A fistula is an abnormal communication between the surface and an internal part of the body, or between two natural cavities or canals. The first form is seen in a rectal fistula, a urethral fistula, or a biliary fistula; and the second form is seen in a vesicovaginal fistula. Fistulæ may result from congenital defect, as when there is failure in the closure of the branchial clefts, and can arise from sloughing, traumatism, and suppuration. Fistulæ are named from their situation and communications. For instance, a pleural fistula, an intestinal or fecal fistula, a rectal fistula, an anal fistula, a gastric fistula, a bronchial fistula, a vesical fistula, a biliary fistula, etc. Many fistulæ are tuberculous and lead to some deeply placed tuberculous focus. A fistula in communication with a viscus (for instance, the gall-bladder) may be maintained by an obstruction of the duct of that viscus the removal of which cures the fistula.

A **sinus** is a tortuous track opening usually upon a free surface and leading down into the cavity of an imperfectly healed abscess. A sinus may be an unhealed portion of a wound. Many sinuses are due to pus burrowing subcutaneously. A sinus fails to heal because of the presence of some irritant fluid, as saliva, urine, or bile; because of the existence of a foreign body, as

dead bone, a bit of wood, a bullet, a septic ligature, etc.; or because of rigidity of the sinus-walls, which rigidity will not permit collapse. Sinuses may be maintained by want of rest (muscular movements) and general ill health. The walls of a tuberculous sinus are lined with a material identical with the Volkmann's membrane of a cold abscess.

Treatment.—In treating a fistula or a sinus, remove any causative obstruction and any foreign body, lay the channel open, curet, brush with pure carbolic acid, and pack with iodoform gauze. In obstinate cases entirely extirpate the fibrous walls, sew the deeper parts of the wound with buried catgut sutures, and approximate the skin surfaces with interrupted sutures of silkworm-gut. To stimulate a sinus to granulation it is sometimes necessary to touch it throughout with the actual cautery, nitric acid, pure carbolic acid, nitrate of silver fused on a metallic probe, or in a solution of a strength of gr. xl to the ounce, or argyrol of a strength of 50 per cent. Fresh air is a necessity to the patient, and nutritious food and tonics must be ordered.

VIII. MORTIFICATION, GANGRENE, OR SPHACELUS.

Mortification, or gangrene, is death in mass of a portion of the living body—the dead portions being large enough to be visible—in contrast to ulceration, or molecular death, in which the dead particles have been liquefied, cannot be seen, and are cast away. When all the tissues of a part are dead, the process is spoken of as *sphacelus*. Gangrene is in reality a form of necrosis, but clinically the term necrosis is restricted to molar death of bone or to death of parts below the surface *en masse*. In gangrene a portion of tissue dies because of anemia, and the dead portions may either desiccate or putrefy. Gangrene may be due to tissue injury, either chemical or mechanical, to heat or cold, to failure of the general health, to circulatory obstruction, to nerve disorder, the nerves involved being the vasomotor or possibly the trophic, or to microbic infection. A microbic poison can directly destroy tissues. It can indirectly destroy them by causing such inflammation that the products obstruct the circulation, but gangrene can occur when no bacteria are present. The essential cause of gangrene is that the tissues are cut off from a due supply of nourishment, and cell-nutrition is no longer possible. In other words, the essential cause of gangrene is the cutting off of arterial blood. Nancrede says: "Indeed, except when the traumatism physically disintegrates tissues, as a stone is reduced to powder, heat or strong acids physically destroy structure, or cold suspends cellular nutrition so long that when this nutrition becomes a physical possibility vital metabolism cannot be resumed, gangrene always results from total deprivation of pabulum." *

Classification.—Gangrene is divided into the following three great groups:

(1) **Dry gangrene,** which is due to circulatory interference, the arterial supply being decreased or cut off. The tissues dry and mummify.

(2) **Moist gangrene,** which is due to interference not only with arterial ingress, but also with venous return or capillary circulation, the dead parts remaining moist.

(3) **Microbic gangrene,** arising from virulent bacteria. In this form the bacterial process *causes* the gangrene, and is not merely associated with it.

The above classification, if unqualified, suggests erroneous ideas. It indicates that there is an essential difference between dry gangrene and moist gangrene, which is not the case. If, when gangrene begins, the tissues are free from fluid, the patient develops dry gangrene; if they are full of fluid, he develops moist gangrene. If the arterial supply is gradually cut off, the tissues are sure to be free from fluid, and the gangrene will certainly be of the dry form. If arterial blood is suddenly cut off, the gangrene may be dry or moist, according as to whether the tissues are or are not drained of fluid. When gangrene results from inflammation, strangulation, and infection, it is certain to be of the moist variety, because the tissues are sure to be filled with fluid.

Nancrede says, in his very valuable work on the "Principles of Surgery": "Yet, let accidental inflammation have preceded the final blocking of an artery, or let ligation of the main artery cause gangrene because the collateral

* "Principles of Surgery."

circulation cannot become developed, and if an aneurysmal sac is so situated as to interfere with a free return of venous blood and lymph, this anemic gangrene will in both instances prove moist and not dry."

There are many gangrenous processes which belong under one or other of the above heads, namely: *congenital* gangrene, a rare form existing at birth; *constitutional* gangrene, arising from a constitutional cause, as diabetes; *cutaneous* gangrene, which is limited to skin and subcutaneous tissue, as in phlegmonous erysipelas; *gaseous* or *emphysematous* gangrene, in which the subcutaneous tissues are filled with putrefactive gases and crackle on pressure; *hospital* gangrene, which is defined by Foster as specific serpiginous necrosis, the tissues being pulpefied: some consider it a traumatic diphtheria; *cold* gangrene, a form in which the parts are entirely dead (sphacelus); *hot* gangrene, which is associated with inflammation, as shown by heat; *dermatitis gangrænosa infantum*, or the multiple cachectic gangrene of Simon; *idiopathic* gangrene, which has no ascertainable cause; *mixed*, which is partly dry and partly moist; *primary*, in which the death of the part is direct, as from a burn; *secondary*, which follows an acute inflammation; *multiple*, as gangrenous herpes zoster; *diabetic* or *glycemic gangrene*, which arises during the existence of diabetes; *gangrenous ecthyma*, a gangrenous condition of ecthyma ulcers; *pressure*, which is due to long compression; *purpuric* or *scorbutic*, which is due to scurvy; *Raynaud's* or *idiopathic symmetrical*, which is due to vascular spasm from nerve disorder; *senile*, the dry gangrene of the aged; *venous* or *static*, which is due to obstruction of circulation, as in a strangulated hernia; *trophic*, which is due to nutritive failure by reason of disorder of the trophic nerves or centers; *thrombotic*, which is due to thrombus; *embolic*, which is due to embolus; and *decubitus*, *decubital* gangrene, or bed-sores due to pressure.

Dry gangrene arises from deficiency of arterial blood. For this reason Nancrede calls it anemic gangrene.

This form of gangrene is far more apt to result from the gradual than from the sudden cutting off of the supply of arterial blood, and is more common if the blood-vessels are atheromatous than if they are healthy; but even in a person with healthy arteries gangrene will ensue upon blocking of the main artery, if the collaterals fail to supply the part with blood. This form of gangrene can occur after laceration, ligation, or the lodgment of an embolus in the main artery of a limb; but in such accidents considerable fluid usually remains in the tissues and the gangrene is apt to be moist rather than dry.

Non-senile Dry Gangrene.—An embolus may cause dry gangrene in rare instances. If it does so, it is probable that the blocking was not at once complete. When an embolus lodges in an artery and causes dry gangrene, the case runs the following course: sudden severe pain at the seat of impaction, and also tenderness; pulsation above, but not below, this point, after obstruction has become complete; the limb below the obstruction is blanched, cold, and anesthetic; within forty-eight hours, as a rule, the area of gangrene is widespread and clearly evident; the limb becomes reddish, greenish, blue, and then black; the skin becomes shriveled and its outer layer stony or like horn because of evaporation. The entire part may become dry; but usually there are spots where some fluid remains, and these spots are soft and moist, and the dead tissue, where it joins the living, is sure to be moist. The moist areas become foul and putrid, but the dry spots do not. In dry gangrene, at

the point of contact of the dead and living tissues, inflammation arises in the latter structures, a bright-red line forms, and exudation and ulceration take place. This line of ulceration in the sound tissues is called the "line of demarcation." It is Nature's effort at amputation, and in time may get rid of a large portion of a limb, and then heal as any other ulcer. A line of demarcation rarely causes hemorrhage, because it ulcerates through a vessel only after inflammation has caused occlusion by thrombosis. In dry gangrene from arterial obstruction there is gastro-intestinal derangement and also some fever. The gangrene does not extend up to the point of obstruction, but only to a region in which the anastomotic circulation is sufficiently active to permit of the formation of a line of demarcation. Below this point inflammatory stasis arises, but before this can go on to ulceration the parts die. In cases where the arterial obstruction is sudden and complete the limb swells decidedly. This is due to the sudden loss of *vis a tergo* in the arterial system, venous reflux occurring and fluids transuding. In such a case the tissues contain fluid and putrefy, and the process, though due to the cutting off of the arterial circulation, is moist gangrene. Dry gangrene attacks the leg more often than the arm. A thrombus in an artery rarely causes gangrene except in the aged, as the collateral circulation has time to adjust itself; but gangrene may follow thrombus formation, and when it does it comes on more slowly than does gangrene from embolus, and is certain to be of the dry form.

Treatment of Non-senile Dry Gangrene.—When injury or blocking of a healthy artery causes us to fear the onset of dry gangrene, the patient should be placed in bed and the part elevated a little, kept wrapped in cotton-wool and surrounded with bottles filled with warm water. If gangrene begins, wait for a line of demarcation, and while waiting dress the dying and dead parts antiseptically, wrap the extremity in cotton and keep it warm, and see to it that the patient gets plenty of sleep and nourishment. It is also advisable to give tonics and stimulants. When a line of demarcation forms, amputate well above it.

Senile gangrene, chronic gangrene, Pott's gangrene (Fig. 78), is a form of gangrene due to feeble action of the heart plus obliterating endarteritis or atheroma of peripheral vessels. The vessels do not carry a normal amount of blood, and may at any time be occluded by thrombosis. In a drunkard, or in a victim of syphilis or tubercle, the changes supposed to characterize old age may appear while a man is young in years. It was long ago said, with truth, "a man is as old as his arteries." Senile gangrene most often occurs in a toe or the foot.

Fig. 78.—Senile gangrene of the feet (Gross).

Symptoms.—A man whose vessels are in the state above indicated is generally in feeble health and has a fatty heart and an arcus senilis (a red or white

line of fatty degeneration around the cornea). His toes and feet are cold and feel numb, and they "go to sleep" very easily, and he suffers from cramp of the legs and feet. He is dyspeptic and short of breath, and his urine is frequently albuminous. The arteries are felt as rigid tubes, like pipe-stems. He is in danger of edema of the lungs and of dry gangrene of the toes. A slight injury of a toe—for instance, cutting a corn too close—will produce extensive inflammatory stasis followed by thrombosis, which completely cuts off the blood-supply and causes gangrene of the part. Gangrene is usually announced by the appearance of a purple and anesthetic spot followed by a vesicle which ruptures and liberates a small amount of bloody serum and exposes a dry floor. In the parts about the gangrenous area there is often burning pain. The circulation in the tissues immediately adjacent to the dead spot is retarded or stagnated, the parts being purple and the color not disappearing or disappearing *slowly* under pressure. If the color fades under pressure it returns *slowly* when pressure is removed. The parts a little further removed are hyperemic, the color disappearing rapidly on pressure, and returning rapidly when pressure is removed. The dead parts do not putrefy at all or do so but slightly, hence the odor is never very offensive and is usually trivial. They are anesthetic, hard, leathery, and wrinkled, and resemble a varnished anatomical specimen or the extremity of a mummy (hence the term *mummification*). Before the line of demarcation forms there is burning pain; after it forms pain is rarely present. If embolism or thrombus in a diseased vessel caused the gangrene, the pain is severe at the point of impaction. In senile gangrene the distal portion of the dead area is always dry, the part nearer the body being generally somewhat moist. The process may be very limited or it may spread up to the knee. As it spreads the area of hyperemia advances at the margin, the area of stasis follows, and the zone of gangrene becomes more extensive. When tissues are reached, the blood-supply of which is sufficiently good to permit of inflammation going beyond the stage of stasis and to allow of stasis without extensive thrombosis, Nature tries to limit the gangrene by the formation of a *line of demarcation*. A line of demarcation may begin, but prove abortive, the tissue mortifying above it. This proves that tissue near the line is in a state of low vitality. The line of demarcation may prove durable and in some few cases spontaneous amputation takes place (Fig. 79). When a limited area is gangrenous, constitutional symptoms are trivial or

Fig. 79.—Dr. Keller's case of spontaneous amputation of a foot and part of a leg in a condition of senile gangrene.

absent; but when a large area is involved, the fever of septic absorption exists. Death may ensue from exhaustion caused by sleeplessness and pain, from septic absorption, or from embolism of internal organs. In many cases of senile gangrene clots are formed in the superficial femoral artery or its branches (Heidenhain), an observation it is important to bear in mind when amputating.

Prevention of Senile Gangrene in the Predisposed.—Such a patient must avoid injuring his toes and feet. Cutting his corns carelessly is highly dangerous, and any wound, however slight, requires rest and antiseptic dressing. The victim of general atheroma must wear woolen stockings, put a rubber bag containing warm water to his feet on cold nights, and attend to his general health. A little whiskey after each meal is indicated, and occasional courses of nitroglycerin are desirable.

Treatment of Senile Gangrene.—When gangrene occurs, if it is limited to one toe or a portion of several toes, if it is a first attack, if there is no fever or exhausting diarrhea, if there is no tendency to pulmonary congestion, if the appetite is fair and sleep refreshing, it is best to avoid radical interference and to await the formation of a line of demarcation. While awaiting the line of demarcation dress the part antiseptically, raise the foot several inches from the bed and surround the part with bottles of moderately warm water. Very warm water may do harm. Give the patient nourishing diet, stimulants, and tonics; see to it that he sleeps, and during the spread of the gangrene watch for fever, diarrhea, pulmonary congestion, and kidney failure. When a line of demarcation forms, dress with warm antiseptic fomentations and iodoform, and every day pick away dead bits with the scissors and forceps. A tendon or ligament should be cut through and a protruding phalanx should be divided with a Gigli saw. If an ulcer forms skin-grafts may be applied. In many cases healing will occur; but even when the parts heal, the patient will always be in deadly peril of another attack. If the gangrene shows a tendency to spread, if it involves more than a portion of several toes, if it is not a first attack, if there is sleeplessness, fever, exhausting diarrhea, anorexia, or a strong tendency to pulmonary congestion, do not delay, but at once amputate high up. If the gangrene shows no tendency to limit itself, or if the patient develops sepsis or exhaustion, at once amputate high up. The best point at which to amputate is above the knee, so that the deep femoral artery, which rarely becomes atheromatous, will nourish the flap and gangrene will not occur. It has been pointed out that the superficial femoral artery and its branches often contain a clot. Never amputate below the tubercle of the tibia. Some operators disarticulate at the knee-joint. Heidenhain affirms that so long as the gangrene is limited to one or two toes we should merely treat it antiseptically, elevate the limb, and wait for the dead part to be cast off spontaneously, if, however, it extends to the dorsum or sole of the foot, we should amputate at once above the knee. He further states that gangrene of the flaps almost always occurs in amputations below the knee, and high amputation is indicated in advancing gangrene with or without fever.* When amputation has been performed and the Esmarch band has been removed and no arterial bleeding takes place from the superficial femoral artery, a clot is lodged in that vessel. If such a condition exist, insert into the artery a fine

* Deutsche medicinische Wochenschrift, 1891, p. 1087.

rubber catheter or a filiform bougie and break up the clot. When blood flows we are sure that the clot has been washed out.*

Moist or Acute Gangrene.—In moist or acute gangrene (Fig. 80) the dead part remains moist and putrefies. As Nancrede points out, there are two forms of moist gangrene: "that limited to the areas actually killed by a traumatism, with some surrounding tissue which dies," and "that which tends to spread widely, this latter being usually caused by specific micro-organisms, an intense, widespread, pyogenic inflammation resulting, involving the subcutaneous and intermuscular cellular planes, by strangulation of the vessels by which all blood-supply to the remaining soft parts is destroyed."† In a case of moist gangrene the parts remain moist, either because the main artery has become suddenly blocked, and the tissue fluids are not urged by sufficient *vis a tergo* to cause them to flow out of the limb, or because the main vein is blocked. It may arise in a limb after ligation, obstruction, or destruction of its main artery, main vein, or both; after long constriction, as by a tight bandage; after crushes and lacerated wounds; and after thrombosis of the vein. Moist gangrene may follow severe pyogenic infection, or may be due to local constriction (strangulated hernia), crushing, chemical irritants, heat, and cold.

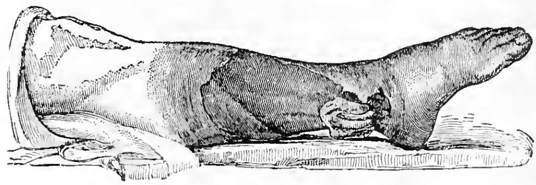


Fig. 80.—Acute gangrene (Gross).

Moist gangrene of a limb may be seen typically in certain cases in which the main vein or artery or both vein and artery are constricted, damaged, or destroyed. The leg swells greatly and is pulseless below the obstruction; the skin, at first pale, cold, and anesthetic, becomes livid, mottled, purple or greenish. A greenish color signifies putrefaction. Blebs are formed which contain a reddish or brown fluid. "These blebs, being caused by the accumulation of serum beneath epithelium which has lost its vital connection with the derm, can be slipped around upon the surrounding true skin, the epithelium readily separating for long distances around, as in a cadaver" (Nancrede). The extremity swells enormously, there may be pain at the seat of obstruction, but there is no pain in the gangrenous area, and sapremic symptoms quickly develop. The bullæ break and disclose the brown derm and sometimes the deeper structures, which are swollen and edematous. The fetor is horrible. Slight or moderate fever usually exist. In mild cases a line of demarcation soon forms. In severe cases in which virulent saprophytes are present the process spreads with great rapidity, neighboring glands enlarge, the temperature is much elevated, no line of demarcation forms, there is profound exhaustion, and gases of decomposition accumulate in and distend the tissues and cause crackling when the parts are pressed upon. Such severe cases are in reality examples of foudroyant or emphysematous gangrene.

Moist gangrene from inflammation is due to pressure of the exudate

*Severeanu. See Mancozet's report before the Second Pan-American Medical Congress.

† Nancrede's "Principles of Surgery."

cutting of the blood-supply, or to loss of blood-circulation because of microbic involvement of vessels and clotting of blood. It occurs typically in phlegmonous erysipelas. When an inflammation is about to terminate in gangrene all the signs of inflammation, local and constitutional, increase; swelling becomes very great and may be due partly to fluid and partly to gas. If gas is present pressure will cause crackling. The color becomes livid or purple. The anatomically related glands are enlarged and the symptoms of sapremia or suppurative fever exist. When gangrene is actually present, the signs of inflammation have passed away, bullæ and emphysema are noted, with great swelling and all the other symptoms of molar death. The sudden cessation of pain is very suggestive of gangrene. The constitutional symptoms are those of suppurative fever and sapremia, or possibly of septic infection.

When a wound becomes gangrenous the surface looks like yellow or gray tow, the discharge becomes profuse and very fetid, and the parts about swell enormously and gradually become gangrenous.

Treatment of Moist Gangrene.—In extensive moist gangrene of a limb, if the condition is of the form described as mild, in which there are not severe symptoms of sepsis and in which the gangrene is not rapidly progressive, wait for a line of demarcation, and amputate clear of and above it. While waiting for the line to form, dress the dead parts antiseptically, wrap the extremity in cotton, apply warmth, and slightly elevate the limb. Give opium, tonics; nourishing food, and stimulants. In the severe form of moist gangrene (really foudroyant gangrene), amputate at once high above the gangrenous process. In inflammatory gangrene, such as is sometimes associated with phlegmonous erysipelas, relieve tension by incisions, cut away the dead parts, brush the raw surface with pure carbolic acid, dust with iodoform, and dress with hot antiseptic fomentations. Stimulate freely, administer nourishment at frequent intervals, and treat the patient in general as we would a case of sapremia, or suppurative fever. A gangrenous wound is treated as pointed out in the section on Sloughing.

Acute microbic gangrene, fulminating gangrene, emphysematous gangrene, gaseous phlegmon, gangrenous emphysema, gangrene foudroyante, or **traumatic spreading gangrene,** results from a virulent infection of a wound. It was first described in 1853 by Maisonneuve under the name of gaseous phlegmon. The condition may be due to a mixed infection with virulent streptococci and organisms of putrefaction; or to infection with the bacilli of malignant edema, and putrefactive organisms. Some case are due to the *bacillus of malignant edema* alone; some are due to the *bacillus aërogenes capsulatus* of Welch and Flexner. These gas bacilli are found in soil in animal and human feces, in street dirt, and the dust of floors. The injury is usually severe—often a crush which destroys the main artery and renders an anastomotic circulation impossible, sometimes a compound fracture or a gunshot wound. In such severe accidents the limb is much swollen and the pulse below the seat of injury is imperceptible, and the surgeon is often at this time uncertain whether to amputate at once or wait. Emphysematous gangrene is commonest after compound fractures, and begins within forty-eight hours of the accident. The extremity becomes enormously swollen from edema and gas. The gangrene does not begin at the periphery, as does ordinary moist gangrene, but at the wound edges, which turn red, green, and finally black;

the extremity soon undergoes a like change and becomes mortified. The skin peels off, emphysematous crackling, due to gas formed and retained in the tissues, can be detected over large areas, and the extremity becomes anesthetic and pulpy. The gases formed in the tissues are sulphid of hydrogen, sulphid of ammonium, volatile fatty acids, and ammonia. Great fetor is soon noted. The gangrene spreads up and down from the wound, and red lines, due to lymphangitis, run from above the wound. The adjacent lymph-glands swell, and in thirty-six hours the gangrene may involve an entire limb. No line of demarcation forms. The system is soon overwhelmed with ptomaïns, and the patient suffers from putrid intoxication, with delirium, and often passes into profound collapse with coma and subnormal temperature. Traumatic spreading gangrene must not be confused with erysipelas. In erysipelas the color is red, pressure instantly drives it out, and on the release of pressure it at once returns. In early gangrene the color is purple, pressure fails to drive it out at all or only does so very slowly, and if the surface is blanched by pressure, on the release of pressure the color crawls slowly back. Sometimes emphysematous gangrene, in the form of gangrenous cellulitis, follows a trivial injury such as a puncture, the entrance of a splinter, an abrasion, or a slight cut. The region about the injury becomes red, then livid, and finally green or black. Enormous swelling takes place, partly due to edema, partly to gas, and the swelling and discoloration spread rapidly. Red lines subsequently becoming greenish run toward enlarged lymphatic glands above the gangrenous part. The tissues are rapidly separated and destroyed and the bone is often quickly exposed and infected. The symptoms point to overwhelming sepsis. There is high fever and delirium, and coma and death are apt to ensue. The patient may die in from twenty-four to forty-eight hours. Welch estimates the mortality from gaseous phlegmon at almost 60 per cent.

Treatment.—In acute spreading gangrene of an extremity following a severe injury no delay is admissible. To wait for a line of demarcation is to expect the impossible, and a delay dooms the patient inevitably to death. Amputation must be performed at once high up, the flaps should be brushed with pure carbolic acid, and then every effort is to be made to sustain the patient's strength by the administration of food and stimulants. Antistreptococcic serum may possibly be useful. In cases of acute spreading gangrene following trivial injuries it may be possible to arrest the process by free incisions, thorough drainage, hot antiseptic fomentations, the continuous hot bath, or continuous antiseptic irrigations, stimulants, etc., but in some cases amputation is necessary. Some surgeons, notably Doerfler ("Münchener medicinische Wochenschrift," April 23 and 30, 1901), oppose amputation in cases of spreading gangrene following trivial or moderately severe injury. Doerfler maintains that cases which recover after amputation would have recovered if amputation had not been performed. From this positive statement I am obliged to dissent.

Hospital gangrene or sloughing phagedena is a disease that has practically disappeared from civilized communities. It formerly occurred in crowded, ill-ventilated hospitals. Some consider it traumatic diphtheria. Koch thinks it is due to streptococci. Jonathan Hutchinson says: "Hospital gangrene is set up by admitting to the wards a case of syphilitic phagedena."

It may show itself as a diphtheritic condition of a wound, as a process in which sloughs which look like masses of tow form, or as a phagedenic ulceration. The surrounding parts are inflamed and painful, and buboes form in adjacent lymphatic glands. The system passes into a low septic state.

Treatment.—In treating hospital gangrene ether should be given, the large sloughs removed with scissors and forceps, the parts dried with gauze and cauterized with bromin. The surgeon should take a tumblerful of water and into it pour the bromin, which will fall to the bottom of the glass. The drug can be drawn up with a syringe and injected into the depths of the wound. The wound should be plentifully sprinkled with iodoform and dressed with hot antiseptic fomentations. When the sloughs separate, the sore can be treated as an ordinary ulcer. The constitutional treatment is that employed for sepsis.

Special Forms of Gangrene.—**Symmetrical** or **Raynaud's gangrene** arises in severe cases of Raynaud's disease. It is a dry gangrene. Raynaud's disease is a vaso-motor neurosis, seen particularly in children and young

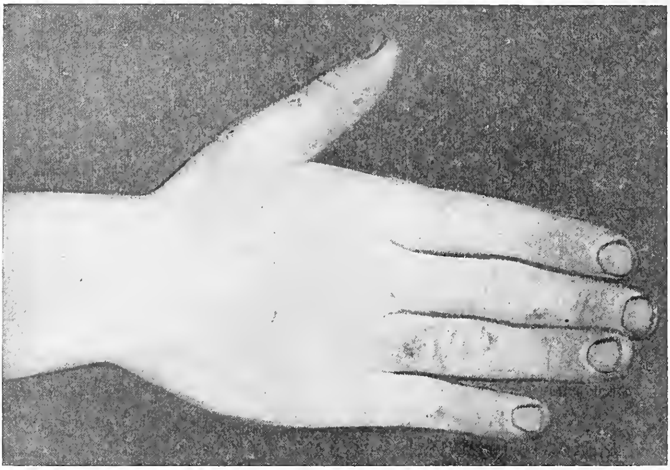


Fig. 81.—Raynaud's disease (Philadelphia Hospital) (Horwitz).

female adults but sometimes met with in men. Chlorotic and hysterical women seem more apt than others to suffer from it. The condition is much commoner in winter than in summer, and cold seems to be an exciting cause. The essential cause of Raynaud's disease is uncertain. In some acute cases associated with fever, albuminuria, and splenic enlargement, it seems to be a part of an acute infectious disease. It can occur in a variety of toxic conditions and in a number of infectious diseases (typhoid fever, for instance). It may develop in the course of gout and also of diabetes. In many cases neuritis exists; in some there is obliterative endarteritis of the peripheral vessels. Some cases seem to be purely hysterical. The fact that attacks of Raynaud's disease are sometimes accompanied by hemoglobinuria has suggested malaria as a possible cause. Raynaud's disease is characterized by attacks of cold, dead bloodlessness in the fingers or toes as a result of exposure to cold, or of emotional excitement (*local syncope*). In the more severe cases there are capillary congestion and mottled, livid swelling (*local asphyxia*).

The patient complains of pain, tingling, numbness, coldness, and stiffness in the affected parts. In some few cases the skin of the face or trunk is attacked. Local syncope is thought to be due to vascular spasm, and local asphyxia to some contraction of the arterioles, with dilatation of the capillaries and venules. It is after local asphyxia that gangrene may appear. A chilblain is an area of local asphyxia. Attacks of Raynaud's disease occur again and again, and may never eventuate in gangrene.

Raynaud's disease is seldom fatal and is often recovered from.

Raynaud's gangrene is most commonly met with upon the ends of the fingers or the toes, but it may attack the lobes of the ears, the tip of the nose, or the skin of the arms or the legs. Sometimes the disease is seen upon the trunk. When gangrene is about to occur the local asphyxia at that point deepens, anesthesia becomes complete, and the part blackens and feels cold to the touch. The epidermis may raise into blebs at the margin of the gangrene, which blebs rupture and expose dry surfaces. A line of demarcation forms, and the necrosed area is removed as a slough. Widespread gangrene from Raynaud's disease is rare; there is not often an extensive area involved—rather a small superficial spot. Recovery is the rule.

Treatment of Raynaud's Disease and of Raynaud's Gangrene.—If an individual suffers from attacks of Raynaud's disease, every effort should be made to improve the general health and to avoid chilling the surface of the body. During the attack employ gentle massage, place the extremity in warm water, and, if pain is severe, give morphia hypodermatically. Amyl nitrite is without value in this condition. When attacks of Raynaud's disease are so severe as to threaten gangrene, put the patient to bed, if the feet are attacked, elevate the legs slightly, wrap the affected extremities in cotton-wool, and apply warmth. If the hands are affected, wrap them in cotton-wool, elevate them slightly, and apply warmth. Massage is useful. When gangrene occurs, dress the part antiseptically until a line of demarcation forms, and then remove the dead parts by scissors, forceps, and antiseptic fomentations. If amputation becomes necessary, which will rarely be the case, wait for a line of demarcation.

Diabetic gangrene resembles in many points senile gangrene, but the dead portions remain somewhat moist and putrefy. Some attribute it directly to the presence of sugar in the blood. Some think diabetes causes gangrene indirectly by rendering the tissues less resistant to infection and less capable than normally of repair. Many hold that it is of neurotic origin, being the result of nerve degeneration. Heidenhain believes that it is due to arterial sclerosis. That most of the victims of diabetic gangrene suffers from arteriosclerosis is certain. It seems probable that the gangrene is due to infection of tissue predisposed to infection by the presence of sugar and weakened by changes in the nerves and blood-vessels. Diabetic gangrene is most usually met with upon the feet and legs of elderly people, but it may arise at any age and may attack the genital organs, thigh, lung, buttock, eye, back, finger, or neck. It may affect only a single area, may attack several areas, or may be symmetrical. It may arise in any stage of diabetes, from the earliest to the latest. It may begin as a perforating ulcer. As in senile gangrene, a trivial injury is apt to be the exciting cause, but it may arise without any antecedent injury. If an injury is causative, a condition like cellulitis arises, spreads

rapidly, and eventuates in gangrene. When the gangrene follows a traumatism, there are no prodromic symptoms. When it arises spontaneously in the skin, it is often preceded by pain of a neuralgic nature and attacks of "livid or violaceous discoloration of the skin, with lowered surface temperature and sometimes loss of sensation" (Elliot). Diabetic gangrene is often superficial, but may become deep if it follows an injury or ulceration. The gangrenous area is somewhat moist as a rule, but may be dry. The parts about are livid and may be covered with vesicles. It spreads slowly, but more rapidly than senile gangrene. There is little tendency to the formation of any line of demarcation, although occasionally spontaneous healing occurs.

Treatment.—Surgeons have become shy of amputating in such cases, but the experience of Küster, of Berlin, proves conclusively that an amputation should be performed at once in diabetic gangrene of the leg, and should be done above the knee. If operation is performed below the knee, the flaps will become gangrenous. It has been noted that sugar will sometimes disappear from the urine after an amputation. Of 11 amputations by Küster, 6 recovered and 5 died; and of these 5, 3 had albumin in the urine as well as sugar.*

Heidenhain warmly advocates early high amputation, with the making of short flaps. When the patient dies after operation, he usually does so in coma. In any case after operation, treat the diabetes by means of drugs and diet. Codein is often of great value. If amputation is refused or if the gangrene is not upon an extremity, treat the gangrenous area by hot antiseptic fomentations, the daily removal of portions of dead tissue, the administration of antidiabetic drugs, and the use of suitable articles of diet. Never fail to examine the urine in every surgical case, and especially in every case of gangrene, for diabetes might be present when it had not been suspected.

Operations on Diabetics.—Surgical operations upon diabetics are regarded as very dangerous and are employed by most surgeons only in emergencies. In operations upon such subjects gangrene may rise in the wound or diabetic coma may develop. It is important to remember that glycosuria may result from a surgical condition (head injury, sepsis, etc.), and this temporary diabetes will be relieved by operation. I have seen it in appendicitis, and in such cases operation is not contraindicated, but is imperative. Llewellyn Phillips in a recent article ("Lancet," May 10 and 17, 1902) refers to the temporary glycosuria produced by injury and sepsis. He thinks that diabetes may directly cause cataract and balanoposthitis, but produces gangrene indirectly by causing nerve degeneration and arteriosclerosis. Phillips points out that a surgical condition and glycosuria may exist independent of and uninfluenced by each other, and many such cases can be operated upon, although operation should be avoided if there is serious disease of some important organ (the liver, for instance). Phillips, in the valuable article referred to, insists that the percentage of sugar is not a measure of the degree of danger; that albuminuria adds greatly to the danger; that the presence of acetone in the urine, and also the presence of ammonia, gives a bad prognosis. Phillips's conclusions as to when to operate and when to refuse operation are as follows ("Lancet," May 10 and 17, 1902): An operation for malignant disease in a diabetic can be performed if the operation would be proper on a non-diabetic individual.

*See the convincing article by Charles A. Powers, in Amer. Jour. of Med. Sciences, Nov. 11, 1892.

Large abdominal tumors can be removed. Cosmetic operations are justifiable if the general health is good and there is not marked arterial disease or nerve degeneration. Operation is justifiable in all emergencies without regard to the condition of the urine. In a diabetic with a surgical malady it is often possible to lessen danger by preliminary treatment. Only an operation of the greatest urgency should be performed if over 1 gram of ammonia is excreted during twenty-four hours; and if aceto-acetic acid or much albumin is present, every case but the most urgent should be postponed and subjected to medical treatment.

I would add to the conclusions of Phillips that the anesthetic is a danger to the kidneys irritated by the secretion of sugar, and it is desirable, when possible, to use local anesthesia, or, as Robt. T. Morris advises, nitrous oxid and oxygen ("Medical News," June 29, 1901). In one case I used spinal anesthesia but the patient died in coma. If sugar diminishes in the urine but increases in the blood the condition is one of danger.

Gangrene from Ergotism.—Ergotism is a diseased condition resulting from eating bread made with rye which has been attacked by a fungus (*Claviceps purpurea*). In former days it was not unusual to have epidemics of ergotism from time to time, but at present the disease is found in individuals or at most in a few of a community. Ergotism is very rare in the United States. It is never seen in unweaned children. The eating of bread made of diseased rye provokes gastro-enteritis, the evidences of which are abdominal pain of a crampy character, vomiting, diarrhea, and exhaustion. The patient complains of formication and itching of the skin of the extremities; severe, cramp-like, and tingling pains in the limbs, and disorders of vision. The pulse becomes small and slow. In some cases very painful spasms attack the muscles of the extremities and finally tonic spasm is noted and the patient probably perishes from exhaustion after developing general convulsions and passing into coma. In other cases certain areas exhibit "gradual blood-stasis" (Osler), anesthesia, and finally gangrene. The gangrene is dry and peripheral. It usually affects the fingers or toes, but may involve an entire limb, and may be symmetrical. Chronic ergotism is usually recovered from, but acute cases die in from seven to ten days.* The ingestion of ergot in quantity sufficient to produce chronic poisoning causes tonic contraction of the peripheral blood-vessels, degeneration of the inner coat, and thrombosis of some arterioles. It is also maintained that degeneration of the posterior columns of the spinal cord takes place.

Treatment.—Ergotism is treated by forbidding the eating of the poisonous bread, allaying gastro-enteric inflammation, favoring elimination, and administering nourishment and stimulants. If gangrene is threatened, endeavor to prevent it by gentle massage and the application of warmth. If superficial gangrene occurs, dress with warm antiseptic fomentations and elevate the part, and every day take scissors and forceps and remove the loose crusts. If deeper and more extensive gangrene arises in an extremity wait for a line of demarcation and amputate above it.

Gangrene from Frost-bite.—Frost-bite is most common in the fingers, toes, nose, and ears, but the genital organs, the cheeks, the chin, the feet and legs, and the hands and arms may be attacked. Cold causes a primary con-

*Pick, in Heath's "Surgical Dictionary."

traction of the vessels and pallor and numbness of the part. After reaction the vessels dilate, the part reddens and swells, and a burning sensation or actual pain is experienced. In a trivial frost-bite the swelling and redness usually disappear after a few days, but in some cases the redness is permanent, and in many cases the redness, in the form of local asphyxia, returns under the influence of slight cold (see Chilblains).

In a more severe frost-bite the affected part becomes purple and covered with vesicles, and gangrene may or may not follow. When a part has been badly frozen the peripheral portion dries. The part is deprived of all blood because of contraction of the vessels and because plasma coagulates at a few degrees above freezing. Cold disorganizes the blood, breaking up white corpuscles with the liberation of fibrin ferment. Coagulation of plasma and destruction of red corpuscles with the liberation of hemoglobin subsequently takes place. The thrombosis which is established prevents circulation, and the tissue-cells are damaged beyond repair. The part is bloodless and anesthetic, and a line of demarcation forms. Hence we note that severe frost-bite causes dry gangrene. If a part which is not so badly frozen is brought suddenly into a warm atmosphere, hyperemia takes place when the blood runs into the frosted tissues, blebs form, and moist gangrene may result. Areas of superficial gangrene are not uncommon.

Treatment of Frost-bite and of Gangrene from Frost-bite.—A frost-bite in which the skin is livid and not as yet gangrenous should be treated by frictions with snow or rubbing with towels soaked in iced water. As the skin becomes warmer and congestion disappears the part should be wrapped in cotton-wool. A sufferer from frost-bite should not suddenly be brought into a warm room. When gangrene follows frost-bite, if only small areas are involved, allow the dead parts to come away spontaneously, applying in the meanwhile hot antiseptic fomentations. If separation be delayed by cartilage, ligament, or bone, cut through the retaining structure. If amputation becomes necessary, await a line of demarcation, as it is not possible otherwise to be certain how high tissue damage extends, and to amputate through devitalized parts would mean renewed gangrene.

Noma.—Noma is a rapidly spreading gangrenous process which is most apt to begin upon the mucous membrane of the gums or cheeks. Noma of this region is known as *cancrum oris*. Occasionally it begins in the ears, the genitals, or the rectum. When it attacks the vulva it is called *noma pudendi*. It may originate in the mouth and subsequently attack other regions. Noma is a very rare disease, is chiefly met with in children between the ages of three and ten, but it can attack older persons. (O. Zusch, in "Münchener medicinische Wochenschrift," for May 14, 1901, reports a case in a man sixty-six years of age.) It occurs in girls oftener than in boys. The disease is most frequently encountered in children recovering from an acute disease. It is seen after scarlatina, typhoid, pneumonia, dysentery, and especially after measles; in fact, Osler says that over one-half the cases follow measles. Children of tuberculous tendencies seem more liable than others. Young children who live amid filth and squalor in damp and ill-lighted apartments are most prone to suffer, but that such conditions are not essential to the genesis of the disease is shown by the report of an epidemic of noma in the Albany Orphan Asylum. In this excellently situated, well-lighted, and well-ventilated

building the children are carefully fed and cared for, and yet 16 cases of noma occurred after an epidemic of measles. (See "An Epidemic of Noma," by Geo. Blumer and Andrew MacFarlane, in "Amer. Journal of Med. Sciences," Nov., 1901.) The disease is thought by many to be due to pus organisms. Lingard describes a bacillus which he considers causative. Blumer and MacFarlane conclude that the disease begins as a simple infection and a mixed infection takes place later. The mixed infection is not always due to the same organism, but is usually due to a long organism of a leptothrix type ("Amer. Journal of Med. Sciences," Nov., 1901).

Symptoms.—The disease begins as a sloughing ulcer, and thrombosis and gangrene soon begin. The edges of the ulcer are dark red and indurated. The gangrene usually spreads with very great rapidity, but in some cases it remains apparently stationary for days at a time. There is little or no pain. The odor is horrible. The disease is frightfully destructive, and if the mouth is involved is apt to destroy the cheeks, lips, eyelids, and large portions of the jaws. There is usually fever, but the temperature may be normal or even subnormal. The pulse is rapid and exhaustion appears early and deepens rapidly. The mortality is large; Bruns says 70 per cent.; Rilliet and Barthez say 95 per cent. ("Amer. Journal of Med. Sciences," Nov., 1901). The cause of death is exhaustion, pyemia, or septic bronchopneumonia.

Treatment.—Administer an anesthetic and destroy the gangrenous area with the Paquelin cautery. In noma of the mouth chloroform is used instead of ether because the hot iron is to be applied in a region surrounded with anesthetic vapor and ether vapor is inflammable. In noma in some other region ether can be given. After cauterization directions are given to wash the part every few hours with peroxid of hydrogen, irrigate it with hot salt solution or boracic acid solution, and dress it with compresses soaked in Labarraque's solution (Blumer and MacFarlane, in "Amer. Journal of Med. Sciences," Nov., 1901). Nourishing food is given at frequent intervals, alcohol is administered, and strychnin is used to combat weakness. If the surgeon succeeds in arresting the gangrene it will probably be necessary later to perform a plastic operation in order to replace loss of substance.

Sloughing is a process by which visible portions of dead tissue are separated. These visible portions are called "sloughs"; if they were large, they would be called "gangrenous masses." A large septic slough is a gangrenous mass; a small gangrenous mass is a slough; there is no difference in the process, which corresponds to the formation of a line of demarcation.

Treatment.—Sloughing requires thorough and frequent irrigation with an antiseptic fluid, removal of the sloughs, and antiseptic treatment. An irrigator can be improvised from an ordinary bottle (Fig. 82). Warm antiseptic fomentations are applied until granulation is well advanced. In some cases continuous irrigation with a hot antiseptic fluid is useful; in other cases continued immersion in a hot antiseptic solution is employed.

Phagedena is a process of ulceration (most common in venereal sores) in which the surrounding tissues are rapidly eaten up, the sore becoming jagged and irregular, with a sloughy floor and thin edges. The discharge is thin and reddish, and the encircling tissues are deeply congested. This ulcer has no tendency to heal. Phagedena may attack wounds, but in this age is almost never seen except in venereal sores. When it does so the wound dis-

charge is arrested, the parts about the wound become dark red and swollen, a black slough forms upon the wound and the process spreads rapidly in all directions. The process when it attacks a wound is similar to or identical with a mild case of hospital gangrene, differing from the gangrene in the fact that in most cases a line of demarcation forms and the depression is not so great. Phagedena is probably due to mixed infection with pus organisms.

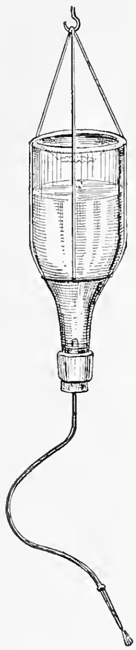


Fig. 82. — Improvised apparatus for the irrigation of a wound.

The **treatment of phagedena** consists in repeated touching with tincture of chlorid of iron and the local use of iodoform, the employment of continued irrigation or immersion in hot antiseptic fluids, or the application of the cautery, chemical or actual. After using the cautery the part is dressed with hot antiseptic fomentations. Whatever else is done, tonics, stimulants, and nutritious diet must be given and opium is often required.

Decubitus, Decubital Gangrene, or Bed-sore.—A bed-sore is the result of local failure of nutrition in a person whose tissues are in a state of low vitality from age, disease, or injury. The arterial condition of the aged favors the development of bed-sores. Such sores are due to pressure, aided it may be by some slight injury or by the irritation produced by urine, feces, sweat, crumbs or other foreign bodies in the bed or by wrinkling of the sheets. The pressure destroys vascular tone, stasis results, thrombosis occurs, and gangrene follows. They occur over the heels, elbows, scapulæ, trochanters, sacrum, and nucha. In some cases, after pressure is removed there are stasis, vesication, suppuration, and the formation of an ugly ulcer, surrounded by a zone of swelling and hyperemia. These ordinary pressure-sores arise like *splint-sores* due to the pressure of a splint upon the tissues over a bony prominence. The pressure interferes with the blood-supply, the weakened tissues inflame, vesication occurs, sloughs form, and an ugly ulcer is exposed. When a bed-sore is about to form, the skin becomes red and edematous. Pressure with the finger drives the color out rather slowly. The color becomes purple or black, a slough forms and separates, and a large, irregular, foul cavity is exposed. The discharge is profuse and offensive. The parts about are swollen and red. If the sore is not upon an anesthetic part, much suffering is produced by it. Bed-sores are most common in paralyzed parts; such parts are anesthetic, and injurious pressure is not painful and does not attract attention, and in such parts there is vaso-motor paresis.

The **acute bed-sores of Charcot** are seen during certain diseases and after some injuries of the nervous system. These sores are usual over the sacrum in acute myelitis, and may appear in four or five days after the beginning of that disease or the infliction of an injury upon the spinal cord. The surgeon sees acute bed-sores upon the buttock of the paralyzed side after brain-injuries, and over the sacrum in spinal injuries. Some believe these sores are due to vasomotor disorder; but others, notably Charcot, attribute them to disturbance of the trophic nerves or centers.

Treatment of Bed-sores.—The "ounce of prevention" is here invalu-

able. From time to time, if possible, alter the position of the patient, keep him clean, maintain the blood-distribution to the skin by frequent rubbing with alcohol and a towel, keep the sheet clean and smooth, and in some situations use a ring-shaped air-cushion to keep pressure from the part. When congestion appears (*paratrimma*, or beginning sore), at once use an air-cushion or a water-bed and redouble the care to frequently change the position of the patient. Not only protect, but also harden, the skin. Wash the part twice daily and apply spirits of camphor or glycerol of tannin; or rub with salt and whiskey (℥ij to Oj); or apply a mixture of ℥ss of powdered alum, f℥ij of tincture of camphor, and the whites of four eggs; or paint with corrosive sublimate and alcohol (gr. ij to ℥j); or apply tannate of lead or equal parts of oil of copaiba and castor oil; or paint upon the part a protective coat of flexible collodion.

When the skin seems on the verge of breaking, paint it with a solution of nitrate of silver (gr. xx to ℥j). When the skin breaks, a good plan of treatment is to touch once a day with a solution of silver nitrate (gr. x to ℥j) and cover with zinc-ichthyol gelatin. We can wash the sores daily with 1 : 2000 corrosive sublimate solution, dust with iodoform, and cover with soap plaster, with lint spread with zinc ointment, or with dry aseptic gauze. When sloughs form, cut most of them off with scissors after cleaning the parts, slit up sinuses, and use antiseptic fomentations. In sloughing Dupuytren employed pieces of lint wet with lime-juice and dusted the sore with cinchona and charcoal. In obstinate cases use the continuous hot bath. When the sloughs separate, dress antiseptically or with equal parts of resin cerate and balsam of Peru. If healing is slow, touch occasionally with a solution of silver nitrate (gr. x to ℥j). Bed-sores, being expressive of lowered vitality, demand that the patient shall be stimulated, shall be well nourished, and shall obtain sound sleep.

Ludwig's Angina (*Angina Ludovici*).—This disease is a streptococcus infection about the submaxillary salivary gland and in the cellular tissue beneath the mucous membrane of the floor of the mouth and of the upper portion of the neck. The inflammation eventuates in suppuration and gangrene. The disease arises as a painful swelling in the neighborhood of the submaxillary gland. The swelling rapidly increases, involves the neck and floor of the mouth, causes great difficulty in opening the mouth and in swallowing and may lead to edema of the glottis.* The constitutional symptoms are those of septicemia or pyemia. The disease may arise in an apparently healthy man or during or after an infectious fever. The streptococci enter from the mouth by way of abrasions, wounds, ulcerations, or dental caries. It may be caused by delayed development of the third molar, necrosis of the tooth and alveolar process taking place and an abscess forming (G. G. Ross, "Annals of Surgery," June, 1901).

Treatment.—At once incise below the body of the lower jaw, open the submaxillary space, cut away gangrenous tissue, paint the wound with pure carbolic acid, pack with iodoform gauze, and apply hot antiseptic fomentations. The constitutional treatment is that of septicemia.

Carbolic Acid Gangrene.—Dressings moistened with a solution of carbolic acid of a strength of from 3 to 5 per cent. may, if wrapped for a number of hours around a finger or toe, cause dry gangrene. There is but

*Tillmann's "Text-Book of Surgery," translated by B. T. Tilton.

little danger when such dressings are applied to the tissues of the trunk, because these thicker tissues are better nourished and cannot be completely surrounded by the wet dressings. The application of strong acid rarely causes gangrene, but Lévan found 14 reported cases in which it did (J. Lévan, in "Centralbl. f. Chir.," August 14, 1897). The continuous application of a weak solution is very dangerous and ought never to be practiced. The author has seen 4 cases. Harrington saw 18 cases of gangrene in five years in the Massachusetts General Hospital, and collected 132 cases from literature ("Boston Med. and Surg. Jour.," May 2, 1901). Carbolic acid gangrene is due to great exudation into the cellular tissue, blocking the circulation (Housell), and the production of arterial thrombi, a condition to which the patient is predisposed by the injury and often by tight bandaging. The dressing is frequently applied by a druggist; it produces anesthesia of the part, and the dressing is often not removed for days although gangrene may be progressing beneath. In the author's 4 cases there was no smokiness of the urine or any other evidence of absorption of the drug.

Treatment.—If the gangrene is very superficial, recovery may be obtained by using hot fomentations and picking the dead parts gradually away. In most cases the finger or toe is completely destroyed, a line of demarcation forms, and amputation is required.

Post-febrile Gangrene.—Dry or moist gangrene may follow any fever, but is most frequent after typhoid (may follow typhus, influenza, measles, scarlet fever, etc.). Keen tells us that the gangrene resulting from arterial obstruction is apt to be dry, and that from venous obstruction is usually moist. The same observer has collected 203 cases.* It is most usual in the lower extremities, but may appear in the upper extremities, cheeks, ears, nose, genitals, lungs, etc. Some writers have assigned as the cause weakness of cardiac action, but most observers believe an obstructing clot is the usual cause. This clot may come from the heart, but is in most cases secondary to endarteritis due to the action of the toxins of the bacilli of the specific fever. Keen shows that in some cases gangrene is due to obstruction of peripheral vessels and not of a main trunk. In rare cases gangrene arises after thrombophlebitis. Gangrene may begin as early as the fourteenth day of the fever, but usually appears late in the disease and may arise far into convalescence. In the course of a continued fever frequent examinations should be made to see that gangrene is not arising. Particular examination from time to time should be made of the lower extremities, and in young girls, of the genitals. If gangrene arises in an extremity, apply antiseptic dressings, wait for a line of demarcation, and then amputate. If gangrene occurs in other regions, remove the dead tissue and employ hot antiseptic fomentations.

Rules when to Amputate for Gangrene.—In *dry* gangrene, due to obstruction of a non-diseased artery, wait for a line of demarcation. In *senile* gangrene, if it affect only one or two toes, let the dead parts be cast off spontaneously. If a greater area is involved or the process spreads, amputate above the knee without waiting for the line. In *ordinary moist* gangrene, if there are not severe symptoms of sepsis, and if the gangrene is not rapidly progressive, wait for a line of demarcation. In the severer cases amputate at once high up. In *traumatic spreading* gangrene amputate at once. In

* Keen on the "Surgical Complications and Sequels of Typhoid Fever."

diabetic gangrene amputate at once, high up. In *ergot* gangrene, in *carbolic acid* gangrene, in *post-febrile* gangrene, in *Raynaud's* gangrene, and in *frost* gangrene wait for a line of demarcation.

IX. THROMBOSIS AND EMBOLISM.

Thrombosis is the ante-mortem coagulation of blood in the heart or in a vessel, the coagulum remaining at its point of origin and plugging up the vessel partially or completely. The process, and also the condition significant of the process, is known as thrombosis; the clot is called the *thrombus*. This process is an essential part in the arrest of hemorrhage; it occurs in phlebitis and arteritis, and affords a frequent basis for embolism. The thrombus is composed of red corpuscles, white corpuscles, fibrin, and platelets in varying proportions. Thrombi may form in the veins, in the arteries, in the capillaries, or in the heart. Clotting is due to destruction of white blood-cells, fibrin ferment being set free, causing the union of calcium and fibrinogen and thus forming fibrin. Thrombosis is more common in the veins than in the arteries, the slow blood-current and the existence of valves favoring the deposit, though not causing it. A thrombus forms gradually, being deposited layer by layer; hence it is stratified or laminated. Fig. 83 shows a thrombus in a vein. All thrombi are either *infectious* or *simple*, the latter being also called *aseptic* or *bland*. Thrombi are also spoken of as fibrinous, red, hemostatic, leukocytic, etc.

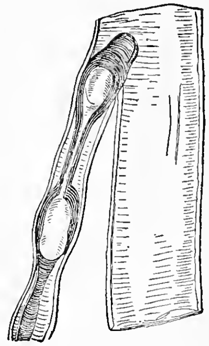


Fig. 83.—Thrombus in the saphenous vein (Green).

Causes of Thrombosis.—In the formation of thrombi four conditions are to be considered, viz., chemical alterations in the blood, a bacterial attack on the intima, tissue changes in the inner coat of the vessel, and slowing of the circulation. One, several, or all of these conditions may exist in a case of thrombosis. In arteries the chief causes are disease of the coats and embolism. In veins the chief causes are injury and infectious phlebitis. Capillary thrombi may be due to propagation from veins or arteries or may form in the capillaries. The latter condition is seldom seen. The essential cause of all intravascular thrombi is damage to the endothelial coat and in most instances the damage is effected by bacteria, hence most cases of thrombosis seen by the surgeon are infectious. Any condition which causes the blood to contain an excess of fibrin-forming elements favors thrombosis, in the sense that a slight injury of the vascular endothelium will be followed by clot formation. Among conditions favoring thrombosis we must note particularly slowing of circulation, however, caused. A special predisposing condition is the retarded circulation in tuberculosis, influenza, and fevers, the blood clotting behind the vein-valves after the endothelium has been damaged by toxins. Among other favoring states are inflammations; wounds; fractures; the pressure of a bandage or of a splint; varicose veins; ligation of a vessel; injury of a vessel; foreign bodies in a vessel; atheroma in arteries; sutures in a vessel; certain diseases, such as gout, typhoid fever, pregnancy, and septic processes; phlebitis or arteritis arising in the vessel or

from extension of surrounding inflammation; and the entrance of specific organisms.

It has been asserted that so long as the endothelium of a vessel is uninjured a clot does not form. Slowing of the blood-current in aseptic conditions, it is now taught, will not cause thrombosis. One of the functions of the endothelial coat is to keep the blood fluid by preventing corpuscular disintegration. A thrombus can form only when fibrin ferment is set free, and fibrin ferment can be set free only when white corpuscles disintegrate. When moving blood coagulates, the third corpuscles or platelets first settle out and form a nucleus and then the leukocytes gather about it. This is known as the *white* or "*antemortem*" *thrombus*—the clot of moving blood. Thrombi from moving blood are rarely pure white; they contain some red corpuscles, forming *mixed thrombi*. White thrombi and mixed thrombi are stratified and are at first soft but harden as they age. The *red thrombus* plugs vessels which are cut across or ligated; it also occurs in septic processes and is formed after death. A *primary thrombus* remains in the original region of thrombosis. A *secondary thrombus* forms about an embolism. A *propagating* or *spreading thrombus* extends a considerable distance from the seat of initial disturbance. A thrombus soon undergoes a change. An aseptic clot usually "organizes"—that is, the clot is absorbed and is replaced by fibrous tissue. The walls of the injured vessel become filled with leukocytes, leukocytes invade the clot, the vascular endothelium proliferates, and the young cells follow the colonies of leukocytes into the thrombus. The thrombus is gradually removed by leukocytes and replaced by fibroblasts, the new tissue is vascularized and becomes granulation tissue, the granulation tissue is converted into fibrous tissue, and the fibrous tissue contracts. In some instances a thrombus is implanted on the wall of the vessel, and the tube is not permanently occluded. Such a condition may be obtained by the application of a lateral ligature about a small tear in a large vein. In most instances, after the formation of an intravascular thrombus, the vessel is converted into a narrow cord of fibrous tissue. A thrombus may degenerate and break down (fatty degeneration), giving rise to emboli or undergoing calcification. A calcified thrombus in a vein is known as a *phlebolith*. An infected thrombus may undergo liquefaction, infective emboli being set free (Fig. 84).

Fig. 84.—Infected thrombus of a vein (schematic).

A clot may propagate in both directions, that is, toward the periphery and toward the center. It was taught for many years that when an artery is ligated a thrombus quickly forms and reaches to the first collateral branch above. This view was formulated in preantiseptic days. It is now known that when aseptic ligation is performed the thrombus is small and rarely reaches the first collateral branch; and is often actually absent, vascular obliteration being obtained by proliferation of connective-tissue cells and of cells from the endothelial coat. If any infection takes place the clot will reach the first collateral branch. The old rule of surgery was as follows: If an artery is cut near a large branch, tie the branch as well as the artery, in order to permit of the formation of a lengthy clot. This rule is no longer followed unless infection exists or is anticipated.

A clot in a vein often extends a long distance. The author has seen in a post-mortem examination a venous thrombus reaching from the ankle to the vena cava. A common example of thrombus in a vein is the clot formed in the uterine sinuses in a condition of puerperal sepsis, a clot which tends to extend into the iliac and femoral veins. In infectious thrombosis of the lateral sinus, thrombophlebitis arises and the clot tends to extend up to the torcular and into other sinuses and down into the jugular. *Phlegmasia alba dolens* or *milk leg* is a condition in which the leg or the leg and thigh are swollen and painful because of venous thrombosis or sometimes lymphatic thrombosis.

Lymphatic Thrombosis.—Occasionally occurs in the thoracic duct, axillary lymphatics, or inguinal lymphatics. It is most common in the uterine lymphatics during puerperal fever. Lymphatic thrombosis may be due to infection, to cancer, to tuberculosis, or to change in the lymph itself.

General Symptoms.—The symptoms are dependent on the seat of the obstruction and the presence or absence of infection. An organ or a part of an organ may exhibit functional aberration. The local signs in a vessel accessible to touch or sight are the presence of a clot; if it be in an artery, anemia and the absence of pulse below the clot; if it be a vein, swelling and edema below it. There is usually pain at the seat of trouble, and anesthesia below it. Moist gangrene may follow venous thrombosis, and dry gangrene, arterial thrombosis. Thrombosis of the mesenteric vein is followed by gangrene of the bowel. Infective thrombophlebitis is a spreading inflammation of a vein. A septic thrombus forms and the condition is an early step in pyemia. We see this condition sometimes in the lateral sinus of the brain as a result of suppuration in the middle ear; in any of the cerebral sinuses after infected compound fracture of the skull; and in the uterine veins in puerperal sepsis. Thrombo-arteritis is a spreading inflammation of an artery in which a septic thrombus forms or in which a septic embolus lodges. It occasionally attacks an aneurysmal sac. In infectious thrombophlebitis and in arterial pyemia the symptoms are, of course, those of pyemia. A great danger of thrombosis is embolism, especially pulmonary embolism.

Infectious Thrombosis of the Lateral Sinus.—(See page 720.)

Thrombosis of the Jugular Vein.—This condition is usually infectious and secondary to infectious thrombosis of the lateral sinus or sometimes of the petrosal sinus. It is occasionally due to cancer, tuberculosis, acute rheumatism, or pyemia taking origin from a distant focus. If it is infectious, the chills, the high and fluctuating temperature, and the great exhaustion proclaim the existence of pyemia. Locally the vein feels hard, the adjacent tissues are edematous, the branches of the jugular are visibly distended, there may be linear discoloration over the course of the jugular, and the head is held stiffly with an inclination to the diseased side.

Thrombosis of the Mesenteric Vessels.—The arteries are affected much more commonly than the veins and the superior mesenteric artery far more often than the inferior. Vascular disease is the cause of arterial thrombosis and arterial thrombosis occurs chiefly in those beyond middle life. Venous thrombosis may be primary and has been observed after splenectomy, the clot having propagated to the mesenteric veins. It may occur as a result of

any gastrointestinal or general infection (pyemia, appendicitis, typhoid fever). Secondary venous thrombosis is due to portal obstruction or accompanies arterial mesenteric thrombosis.

Mesenteric thrombosis usually produces sooner or later gangrene of the gut, but does not always do so.

The period at which gangrene develops after blocking is uncertain; it may arise in thirty-six hours, it may not arise for two weeks or more. The gut becomes distended, bloody serum exudes into the peritoneal cavity, and in most cases into the lumen of the bowel. The mucous membrane undergoes necrosis and perforation occurs. The area involved varies greatly in different cases. In some cases it is very limited, and is rather apt to be in the large intestine. In other cases it is very extensive, and is apt to be in the small intestine. In a case of the author's in the Jefferson College Hospital practically the entire ileum was gangrenous and numerous perforations existed.

In mesenteric thrombosis pain arises rather suddenly and rapidly becomes severe. It is a persistent pain with paroxysmal exacerbations and is usually generalized, though in many cases it has an area of peculiar intensity. The pain is accompanied by rapid pulse, growing exhaustion, distention, subnormal temperature, tenderness, a mass appreciable by palpation in the region of the mesentery, free fluid in the peritoneal cavity, nausea, and vomiting. The condition suggests intestinal obstruction. The vomited matter consists first of the contents of the stomach, then of bile, finally becomes stercoraceous, and sometimes contains blood.

In nearly one-half of all cases blood in considerable quantity passes from the rectum.

Ballance points out that cardiac disease or arterial degeneration suggests the artery as the seat of thrombosis.

The only chance for recovery without operation is the establishment of the collateral circulation, and as the superior mesenteric vessels are terminal vessels this seldom occurs (in only about 5 per cent. of cases).

Thrombosis after Abdominal Operations.—This complication is occasionally encountered and is most often met with in the left side, even when the operation was in the middle line or the right side. It is a rare complication, occurring, according to Professor Clark, 35 times in a series of 3000 operations.

Many explanations have been given of it. A great many surgeons regard it as infectious, but many cases certainly are not. Clark believes it is due to injury of the deep epigastric vein, forcible and prolonged separation of the wound edges by retractors being a common cause. The free anastomosis between the epigastric veins of the two sides accounts for the appearance of thrombosis on one side after operation on the other. It probably in many slight cases is not recognized and it will not be recognized unless the clot reaches the femoral vein, and it requires one or two weeks to reach this vein if it does so at all. When a clot forms in the femoral vein a milk leg develops. The entire extremity swells below the seat of thrombus, the temperature is usually normal but may be slightly elevated.

Thrombosis in General Infections.—In *typhoid fever* a thrombus may form in the heart, the veins or the arteries. Thrombosis may occur in pneumonia, in influenza and in other fevers, and in tuberculosis. The vessels of a limb, a lung, the brain or the mesenteric zone may suffer. The condition

follows bacterial infection, the veins are most prone to suffer and gangrene may ensue.

Thrombosis in Appendicitis.—In about 2 per cent. of cases, according to Sonnenberg, this complication is noted. It may affect the femoral or saphenous vein of either side or of both sides, the portal vein or the vena cava, and may occur during an acute attack but is more often noted in an interval.

It is not very unusual to find a liver abscess follow appendicitis, the infection being carried by the portal vein and the condition being known as *septic pylephlebitis* (page 878).

Treatment.—If an aseptic thrombus forms in a large vessel of a limb, raise the limb a few inches from the bed, keep it perfectly quiet to avoid detachment of fragments (emboli), apply a bandage lightly from the toes up, and place warm bottles around the extremity. Maintain rest for four or five weeks. The great danger is the formation of emboli, hence movements and rough handling are to be avoided. Gangrene is another danger, hence it is wise to favor venous return and the development of the collateral circulation by warmth, elevation, and bandaging. In infectious thrombophlebitis, if the vessel is accessible, tie it above and below the clot, open the vessel, remove, irrigate, and pack the wound with iodoform gauze. The general treatment for a septic condition should be stimulating and supporting. Massage is unsafe in any condition of thrombosis, and is particularly dangerous in septic thrombosis. In thrombo-arteritis treat as in the thrombo-phlebitis. If gangrene of an extremity follows thrombosis treat as previously directed (page 169). Gangrene of the intestine in mesenteric thrombosis if not too extensive is treated by resection.

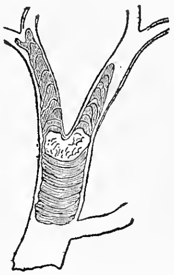


Fig. 85.—Embolus impacted at bifurcation of a branch of the pulmonary artery (Green).

The treatment of infectious thrombosis of the lateral sinus is set forth on page 721.

Embolism signifies vascular plugging by a foreign body (usually a blood-clot) which has been brought from a distance. The foreign body is called an *embolus*. An embolus usually consists of a separated or ruptured portion of a thrombus, atheromatous material from a diseased artery, or a bit of fibrin from a diseased heart valve. In some cases an embolus consists of bacteria, or air, or fat, of a fragment of a tumor, or of parasites. In severe burns the blood undergoes changes and jelly-like matter is often precipitated and may cause embolism. Emboli vary in shape, in size, and in consistency. Emboli are divided into *simple*, *bland* or *aseptic* and *infectious*, *toxic* or *septic*. Emboli may arise either in the venous or in the arterial system, but are particularly prone to arise in the veins; they lodge in an artery, in capillaries, or in the veins of the liver. An embolus taking origin in one of the systemic veins passes through the right heart and lodges in a terminal branch of the pulmonary artery. If at this point it disintegrates, smaller emboli pass to the left heart and enter the arterial circulation to be deposited, as are emboli originating in the heart or arteries, in the arteries of an extremity, the kidneys, spleen, or brain. Emboli of the portal circulation lodge in the liver or perhaps pass through that organ and reach the lungs. An embolus is arrested when it reaches a vessel whose diameter is less

than its own. It is usually caught just above a bifurcation. When an embolus lodges, it at once partially or entirely obstructs the circulation, and increases in size by thrombosis. Fig. 85 shows an impacted embolus. A non-septic embolus when lodged usually "organizes," as does a thrombus, and, as described on page 122, is replaced ultimately by fibrous tissue. A soft embolus may disintegrate and permit the re-establishment of the circulation. An embolus may cause an aneurysm. A septic embolus breaks down, forms a metastatic abscess, and sends other emboli onward in the blood-stream.

An embolus is more serious than a thrombus: it causes sudden plugging, which makes dangerous anemia inevitable, and it will produce gangrene if the collateral circulation fails. Embolism of the mesenteric artery causes necrosis of the intestine. In organs with terminal arteries (spleen, kidney, brain, and lung) there is no collateral circulation and embolism causes *infarction*. For instance, if an embolus lodges in the lung it produces an area of anemia; the removal of all propulsion upon the venous blood causes it to flow back and stagnate, and vascular elements exude, forming a wedge-shaped area of red tissue, the embolus being the apex of the wedge. This is known as *hemorrhagic* or *red infarction*, and is often seen in the lung (Fig. 86). The *white infarction*, seen in the brain and kidney, is not due to retrogression of venous blood, but is due to anemia and resulting coagulation-necrosis. A septic embolus causes septic thrombosis and a septic infarction, and a septic infarction is followed by suppuration and the production of a pyemic abscess. That emboli of the systemic venous circulation usually lodge in the lungs explains the occurrence of pulmonary embolism after certain operations upon and during certain diseases of the regions drained by the systemic veins.

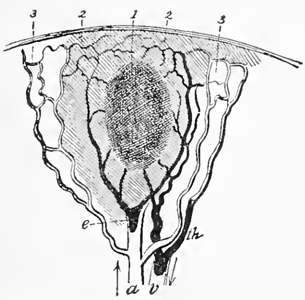


Fig. 86.—Diagram of a hemorrhagic infarct: *a*, Artery obliterated by an embolus (*e*); *v*, vein filled with a secondary thrombus (*th*); *1*, center of infarct, which is becoming disintegrated; *2*, area of extravasation; *3*, area of collateral hyperemia (O. Weber).

Emboli formed in vessels of the systemic circulation lodge most often in the lungs, brain, kidney, or spleen. It is because emboli which pass into the portal vein lodge in the liver that operations upon the rectum may be followed by hepatic embolism and abscess of the liver.

General Symptoms.—The symptoms depend upon the organ involved and the presence or absence of infection. They are sudden in onset, and are due to loss of function, which may be permanent or which may be followed by inflammation, softening, or gangrene. In a septic embolus there are symptoms of infection and abscess forms at the seat of lodgment. In the course of pyemia a chill usually means the occurrence of embolism. Embolism of the cerebral arteries may cause aphasia, paralysis, or coma. Embolism of the pulmonary artery may cause almost instant death. Embolism of a large artery of a limb produces symptoms identical with thrombus, except more sudden and decided. Below the obstruction the pulse is absent and the limb is swollen with edema, is cold, and is discolored. There is pain at the seat of obstruction. This condition is frequently followed by gangrene.

Embolism of the superior mesenteric artery produces symptoms similar to those caused by acute intestinal obstruction, and results in gangrene of a portion of the intestine.

Pulmonary Embolism.—This condition occasionally follows operations and injuries and sometimes develops during certain diseases. I have seen a case after an operation for appendicitis, a case after an operation for varicocele, and a case in a man with a large lumbar contusion to which massage was injudiciously applied. It is not very common. Albanus ("Beiträge klin. Chir.," xl) in 1140 abdominal operations found 23 cases. The emboli may be aseptic or septic. The condition is most common as a result of thrombosis of the veins of the lower extremities, appendicitis, and strangulated hernia. Certain post-operative pneumonias are embolic. Very small aseptic emboli may cause no symptoms or slight symptoms. When aseptic hemorrhagic infarction occurs there are symptoms. These symptoms are a chill or a crawl, moderate fever which may be transitory, dyspnea, rapid pulse, pain in the chest, sometimes rapidly advancing signs of consolidation, often a pleural friction sound, and bloody expectoration. Sometimes immediate death occurs. The mortality is always large (80 per cent.).

A septic embolism causes metastatic abscess and usually suppurating pleuritis, the condition being known as septic embolic pneumonia. Recovery is rare but occasionally occurs. The symptoms are those of pyemia with the physical signs of consolidation and of pleuritis.

Embolism of the Mesenteric Arteries.—The superior mesenteric is the vessel usually affected. It may arise in pyemia, septicemia, arterial or cardiac disease. The symptoms are practically identical with thrombosis of the mesenteric vessels (page 187).

Treatment.—The treatment of aseptic embolism depends upon the part involved. In a limb, keep the part warm in order to stimulate the collateral circulation, elevate the extremity several inches from the bed, apply a bandage lightly from the periphery, and insist on perfect quiet. Massage is unsafe. If gangrene ensues, await a line of demarcation and amputate. In septic embolic arteritis in an accessible region it would be good surgery to act as in septic thrombophlebitis. After an operation upon veins (as the operation for varicocele, for varix of the leg, or for hemorrhoids), after any cutting operation, and after the infliction of a fracture, avoid as much as possible, and for some time, movements or handling, as fragments of thrombus may be detached.

In mesenteric embolism exploratory laparotomy may disclose a perforation which can be closed or a portion of gangrenous gut which can be resected.

In aseptic pulmonary embolism enforce absolute rest, give strychnin and morphia hypodermatically, and inhalations of oxygen.

In septic embolic pneumonia, pursue the same plan of treatment, unless a large pulmonary abscess forms or an empyema arise. In either case operate.

Fat-embolism in the human being was first thoroughly described by von Recklinghausen in 1884. Magendie years before developed it experimentally in animals (Frazier). It is a process which leads to an accumulation in the capillaries of liquid fat after injuries of adipose tissue, high tension having forced the fat into the open mouths of veins. Some little fat may get into the blood by means of the lymphatics. Fat-embolism occasionally arises dur-

ing osteomyelitis, after extensive bruises, crushes, or lacerations, and after amputations, fractures, resections, or rupture of the liver.* In a case of mine it developed as a result of manipulation of a fracture of the neck of the femur. In another case it followed amputation of the breast for cancer. This fluid fat accumulates especially in the capillaries of the lungs and brain. It may plug systemic capillaries. If the patient recovers, he does so because the fat has been forced through the vessels; if he dies, the death results from mechanical hindrance to function and nutrition. Normal blood contains a small amount of finely emulsified fat (from 1 to 3 parts per 1000). In a number of physiological and pathological conditions the circulating blood contains considerable free fat. It may be found in a pregnant woman, a nursing baby, a fat individual, or in anyone during digestion. "It has been noted in the following conditions: chronic alcoholism; diabetes mellitus; certain diseases of the liver, heart, and pancreas; chronic nephritis; splenitis; tuberculosis; malarial fever, typhus fever, Asiatic cholera; and poisoning by phosphorus and by carbon monoxid. Lipemia commonly occurs as the result of lacerated wounds of the blood-vessels situated in fatty tissue, and after fractures of long bones involving injury of the fatty matter" ("Clinical Hematology," by John C. DaCosta, Jr.). In many cases of fracture in adults fat is found in the urine. I have had this demonstrated by repeated observations. When we recall how rarely simple fracture causes death it becomes evident that a moderate amount of fat in the blood is not dangerous or only becomes dangerous if it fails to flow out. In lipemia fatty embolism may occur if the amount of fat becomes excessive or if vascular damage favors plugging.

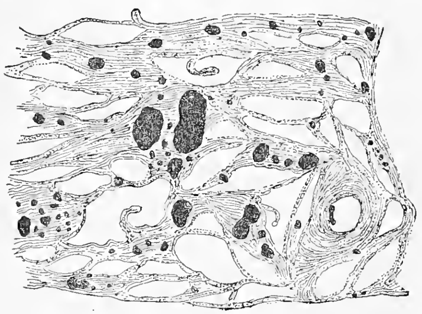


Fig. 87.—Fat-embolism of the lung after fracture of the femur. The fat-globules and masses, stained black with osmic acid, lie in the capillaries of the lung. × 150. (Hektoen.)

Symptoms.—The symptoms are those of edema of the lungs and exhaustion, often with coma or delirium, and sometimes, in the beginning, are wrongly thought to be due to shock. There are restlessness, dyspnea, rapid pulse and respiration, normal or subnormal temperature, and pallor followed by cyanosis. The chest exhibits many coarse râles, but on percussion gives a clear note. If pulmonary edema becomes marked, the patient spits up a bloody froth. If life is prolonged a day or two, oil is found in the urine. Small amounts of oil may be found in the urine after serious injuries or operations when no symptoms of embolism exist. For instance, for two or three days after a fracture it is often present. Nevertheless, the presence of the oil is always a cause of anxiety, and is often a warning. It is maintained by Groubé that the amount of fat in the urine is in inverse ratio to the amount in the blood; the greater the amount excreted in the urine, the less the amount retained in the blood. Hence, fat in the urine makes the surgeon anxious, and a *sudden* diminution of the amount in the urine is a sign of grave danger if there develops increasing difficulty in respiration ("Rev. de Chir.," July, 1895). The inverse ratio said to be main-

*G. H. Makins, in Heath's Dictionary.

tained between fat in the blood and fat in the urine, if it really exists, is similar to a finding of Lépine in diabetes, that is, if a diabetic is given diuretics, the sugar in the urine increases and the sugar in the blood decreases. The symptoms of fat-embolism never occur until at least twelve hours after an accident, and rarely before the third day. The symptoms occur at a later period than those of shock, and at an earlier period than those of ordinary embolism of the lung. If some of the oil is forced through the vessels of the lung, it will lodge in other regions and produce other symptoms. Oil may appear in the urine as above stated. Urinary suppression may occur. Delirium may arise, there may be twitching, convulsions, or paralysis, or the patient may pass into coma. Severe cases of fat embolism are commonly fatal; milder cases are often recovered from. I have lost a case operated upon for carcinoma of the breast and also a case of fracture of the femoral neck from this cause.

Treatment.—The treatment consists in absolute rest of the diseased or injured part and the administration of stimulants, such as strychnin, alcohol, and carbonate of ammonium, the use of external heat; the employment of oxygen by inhalation; and the administration of diuretics and of nitroglycerin hypodermatically. Artificial respiration may tide a patient over a crisis. If an external wound exists, free drainage must be established, and the diseased or damaged part should be thoroughly immobilized if possible. In order to prevent fat-embolism after a severe injury insist on rest. Massage used early after some injuries is dangerous, as it may force fluid fat into the vessels. When severe contusion causes the formation of a large cavity filled with blood, Groubé wisely advises incision, to lessen the danger of fat-embolism.*

Air-embolism.—Air may enter a vein during a surgical operation or it may be injected accidentally while giving a hypodermatic injection, hypodermoclysis, or a saline infusion into a vein. It may follow irrigation of the pleura with hydrogen peroxid (Janeway). In caisson disease it is taught by some that nitrogen is set free in the blood. It may occur when a cerebral sinus is opened, or in the uterine veins, if the uterus does not remain contracted after delivery. It is very seldom that any symptoms follow. It was long thought that such an accident must be extremely dangerous. The experiments of my colleague, Professor Hare, indicate that quantities of air may be injected into the veins of a dog without apparent harm. The entry of a small amount of air into the veins of a human being will not be apt to induce dangerous symptoms, but it may be fatal. The more rapidly it is introduced and the greater the amount, the greater is the danger. The manner in which it can induce death is doubtful. Some maintain that it causes the blood in the right side of the heart to froth, and thus prevents normal action of the valves, the heart becoming unable to propel blood through the lungs. Others maintain that air reaches the cerebral capillaries and so causes cerebral anemia. Some believe cardiac failure results from air in the pulmonary capillaries. The first view is the most probable. If a surgeon divides a large vein, air may be sucked in, and there is particular danger in such an accident if a vein at the root of the neck or a cerebral sinus is torn or incised, or if the damaged vessel lies in scar tissue and cannot collapse.

Symptoms.—When during an operation air enters a large vein

* Rev. de Chir., July, 1895.

there is a sucking sound, air bubbles may be noted in the wound, and serious symptoms may or may not follow. Twice I have wounded the subclavian vein and have heard this sound, but no alarming symptoms developed. If serious symptoms are produced, they arise suddenly, and consist of extreme failure of circulation, a curious whirring or churning sound on cardiac systole audible even without a stetoscope, deadly pallor or cyanosis, gasping for air, convulsions, and possibly death.

Treatment.—Compress the vein with the finger and clamp it quickly. Suspend the anesthetic, lower the head, employ artificial respiration and inhalation of oxygen, and give strychnin hypodermatically.

X. SEPTICEMIA AND PYEMIA.

Septicemia, or sepsis, is a febrile malady due to the introduction into the blood of pyogenic organisms or the products of pyogenic organisms or of saprophytic bacteria. There is no one special causative organism, and any microbe which produces inflammatory and febrile products may cause it. Either streptococci or staphylococci may be present. Pneumococci are a not very unusual cause. Septicemia arises by absorption of septic matter by the lymphatics. Clinically we distinguish two forms of septicemia: (1) sapremia, septic or putrid intoxication; and (2) septic infection, true or progressive septicemia. In these conditions the area of infection is usually discovered by the surgeon; but when it cannot be located, the disease is called by the Germans cryptogenetic septicemia.

Sapremia, Septic or Putrid Intoxication.—This condition is due to the absorption of poisonous ptomaïns from a putrefying area. The bacteria do not enter the blood, but their toxins do, and, as these toxins are active poisons, the condition is comparable to poisoning by successive alkaloidal injections, the symptoms and prognosis depending upon the dose. Not unusually there is absorption not only of the toxins of saprophytic bacteria, but also the toxins of pyogenic micro-organisms. Even if some of the bacteria enter the blood, they do not multiply in this fluid. Slight symptoms and recovery follow a small dose; grave symptoms and death follow a large one. The poison does not multiply in the blood, and a drop of the blood of a person laboring under putrid intoxication will not produce the disease when introduced into the blood of a well person; in other words, the disease is not infective. Considerable putrid material must be absorbed to cause sapremia. What is known as surgical fever is due to the absorption of a small amount of putrid or fermented wound fluid, and is in reality a mild form of sapremia. If sapremia arises, it does so soon after the infliction of a wound, and after a large rather than small wound, when a considerable amount of wound fluid is pent up under pressure. It may follow labor where putrid fluid is retained in the womb, may follow an injury of or an operation upon a joint, may follow amputation where decomposing blood-clot or wound fluid is pent up within the flaps, or may ensue upon an abdominal operation or injury. In sapremia there always exist a considerable absorbing surface and a large amount of dead matter which has become putrid. Roswell Park * points out that sapremia arises from putrefaction of a blood-clot or wound fluids which are retained like foreign bodies in the tissues, and does not arise from putrefaction of the tissues themselves. He speaks of the condition as due to the absorption of poison from a "putrid suppository." Sapremia will not occur after granulations form. The term putrefaction is used because this is the usual change, but any fermentative organism may cause the disorder. Sapremia is a malignant form of surgical fever, and its existence means an ill-drained wound, and a fermenting and probably putrid collection of blood-clot or wound fluid.

In sapremia there is congestion of the stomach, intestines, and other abdominal viscera, particularly the kidneys, and also of the brain, and numbers of red blood-cells disintegrate.

* "Treatise on Surgery by American Authors."

Symptoms.—The patient often seems to react incompletely from the injury; he feels miserable, complains of headache, nausea, and pain in the back and limbs; or, he may react and in a day or two develop this condition of malaise. In some cases an aseptic fever is directly succeeded by sapremia. In most cases of sapremia, between twenty-four hours and two or three days after labor, after an injury, or after an operation, there is a chill, or at least a chilly sensation, though in some cases this is wanting. The temperature rapidly rises to 103° F. or even more. There are severe headache, dry and coated tongue, rapid and weak pulse, nausea, and often vomiting, diarrhea, great prostration, restlessness, muscular twitching, and active delirium. The wound is found to be foul, and commonly there is drying up of wound discharge. There is diminution or suppression of urine, and a strong tendency to congestion of various organs. Jaundice is not unusual. Petechial spots are frequently noticed upon the skin. They occur also upon mucous membranes and serous surfaces, and result from the plugging of small vessels with detritus of broken-down red corpuscles and consequent vascular rupture. Great elevation of temperature often precedes death. In some cases the dose of poison is so large that the patient passes into rapid collapse without preliminary fever. Some cases recover if the initial dose is not overwhelming and if additional doses are not absorbed. Many cases die of exhaustion. Some become linked with fatal pyemia or septicemia. Hemoglobin and red blood-corpuscles are rapidly and notably diminished. Distinct leukocytosis exists, except in those cases in which the organism is overwhelmed with the poison and is unable to react. Cover-glass preparations do not show organisms, and cultures from the blood are sterile.

Treatment.—The treatment consists in at once draining and asepticizing the putrid area and administering very large doses of alcohol and large medicinal doses of strychnin and digitalis. The patient should be purged and diaphoresis favored. The hot bath is valuable to cause sweating. The action of the kidneys must be maintained if possible. Purgatives, diuretics, and diaphoretics are given to aid in removing the toxin, and stimulants are used to sustain the strength of the patient during the elimination of the poison. Vomiting is allayed by champagne, cracked ice, calomel, cocain, or carbolic acid with bismuth. Food should be administered every three hours. The patient is fed on milk, milk and lime-water, liquid beef-peptonoids, beef-juice, and other concentrated foods. Quinin in stimulant doses is of value. Antipyretics are useless. The use of saline fluid by hypodermoclysis or intravenous infusion dilutes the poison and stimulates the heart, skin, and kidneys to activity. Visceral complications must be watched for and should be promptly treated if discovered. Among the possible visceral complications are nephritis, cholecystitis, enteritis, hepatitis, peritonitis, pleuritis, empyema, bronchopneumonia, pericarditis, and endocarditis. Antistreptococcic serum is useless in sapremia.

Septic Infection, or True Septicemia.—This condition is a true infective process. In sapremia the blood contains toxins of putrefactive bacteria, but not the bacteria themselves. In septic infection the blood contains both pyogenic toxins and multiplying pyogenic bacteria, the bacteria perhaps being free in the blood or in white cells. In sapremia the causative condition is putrid material lodged like a foreign body in the tissues. In

septic infection the tissues themselves are suppurating, and both bacteria and toxins are being absorbed by the lymphatics. Of course, septic infection may be associated with septic intoxication or may follow it. In suppurative fever the tissues suppurate, but only the pyogenic toxins are absorbed, and not the pyogenic bacteria. In septic infection both the pyogenic bacteria and toxins enter the blood, and the bacteria multiply in the blood and produce continually increasing amounts of poison. The symptoms of sapremia depend on the dose. In septic infection only a small number of organisms may get into the blood, but they multiply enormously. The pus microbes cause true septicemia, and reach the blood chiefly through the lymphatics, but to some degree by penetrating the walls of vessels. A drop of blood from a man with septic infection will reproduce the disease when injected into the blood of an animal; hence the disease is truly infective. The wound in such cases is often small, but may be large, and is commonly punctured or lacerated, and the disease begins later after the infliction of a wound than does sapremia. No wound may be discoverable, the infection having arisen from an unrecognized focus of suppuration—for instance, gonorrhea, middle-ear disease, dental caries, tonsillar suppuration, appendicitis, etc. Septicemia in which the initial atrium of infection is not discovered is called cryptogenetic septicemia.

The bacteria which exist in the blood and organs in septicemia are usually staphylococci or streptococci, often both. Pneumococci or colon bacilli in some cases are causative. The blood is found to have lost much of its coagulating power; it remains fluid for some time after death, quantities of red corpuscles are destroyed, and minute hemorrhages take place in the brain, mucous membranes, skin, serous membranes, muscles, and various viscera. There may be inflammation of synovial and serous membranes. There is congestion of the gastro-intestinal tube and of the abdominal viscera. The lymph-glands are larger than normal and the spleen is notably enlarged. The wound contains numbers of bacteria.

Symptoms.—The type of this condition is met with in puerperal septicemia or in septicemia from an infected wound. When septicemia arises from an infected wound, red lines due to lymphangitis are usually seen about the wound, and there is enlargement of related lymphatic glands. In some cases, however, the wound and the parts about it look normal. A supposed aseptic fever after an injury may continue for an undue time and the surgeon may find that septicemia has developed. Septicemia may arise during the existence or after the abatement of sapremia, or may arise when the aseptic fever has passed away and when there has been no putrid intoxication. It begins in from four to seven days after labor or an injury, usually with a chill, which is followed by fever, at first moderate, but soon becoming high. In some cases there is a chilly sensation, but no distinct chill. There is always great prostration even before the chill. The fever presents morning remissions and evening exacerbations, and may occasionally show an intermission. When the remission begins there is a copious sweat. As the case progresses the temperature may fluctuate, and it often rises very high before death. The pulse is small, weak, very frequent, and compressible. The tongue is dry and brown, with a red tip. Sordes gather on the teeth and gums. Vomiting is frequent, and, as a rule, there is diarrhea. Low delirium alternates with

stupor, and coma is usual before death. The great prostration is a noticeable and characteristic feature of the sufferer from septicemia. There are *subsultus tendinum* (twitching of the muscles of the hands and feet) and *carphologia* (picking at the bedclothing). Toward the end the face often becomes *Hippocratic* (hollow temples, pinched nose, sunken eyes, livid skin, lead-colored and cold ears, and relaxed lips). Visceral congestions occur. The spleen is enlarged, ecchymoses and petechiæ are noted, urinary secretion becomes scanty or is suppressed, and the wound becomes dry and brown. Blood-examination detects a rapid and great diminution in red corpuscles and hemoglobin. The anemia is in many cases profound. There is marked leukocytosis except when the system is overwhelmed by the poison. Cover-glass preparations made from blood may show bacteria, but often fail to do so. Cultures from the blood are sterile in most cases, but not in all. A negative finding does not disprove the existence of septic infection; a positive finding is of conclusive diagnostic value. Pneumococcic septicemia is extremely violent in manifestation. In some cases death ensues before the lung has consolidated. If it is not so rapid endocarditis, arthritis, peritonitis, meningitis, or osteomyelitis may develop.

The *prognosis* of true septicemia is very unfavorable, and in some malignant cases death occurs within twenty-four hours, but mild cases often recover. Welch points out that finding the staphylococcus pyogenes albus in the blood is not particularly ominous, but the presence of other pyogenic cocci is exceedingly threatening. Endocarditis, pericarditis, peritonitis, pleuritis, bronchopneumonia, empyema, nephritis, arthritis, cholecystitis, hepatitis, meningitis, and pyelitis are among the complications which may arise.

Treatment.—The treatment in general is the same as for septic intoxication. Antistreptococcic serum is employed by some surgeons, but the value of this method is as yet doubtful. It does not do any harm. It may do good. It is proper to use it, but not to the exclusion of other remedies. The usual dose is 10 c.c. injected into the abdominal wall. The injection may be repeated two, three, or even six times a day, and may be used for a number of days. Washing the blood by the intravenous infusion of salt solution often produces distinct improvement, which, unfortunately, is usually temporary. Dr. C. C. Barrows commends formalin used intravenously. The strength of the solution is 1 part of formalin to 5000 parts of salt solution. The dose is 500 c.c. I have had no experience with formalin in septicemia, but do not believe that any agent can be safely introduced which would rapidly and directly kill the bacteria even if such an agent could be found, the attempt to use it would be dangerous as dead bacteria liberate a poison and the rapid death of immense numbers of bacteria would mean the entrance into the blood of an enormous amount of toxic matter.

Pyemia.—Pyemia is a condition in which metastatic abscesses arise as a result of the existence of septic thrombophlebitis, the disease being characterized by fever of an intermittent type and by recurring chills. It is not actually due to free pus in the blood, but to the passage into the blood of clots filled with toxins or, far oftener, infected by streptococci or staphylococci, or both. After a wound is inflicted blood clots in the divided veins. If suppuration occurs, the clots may become filled with the toxins of pyogenic bacteria or be invaded by the bacteria themselves. Thus it becomes evident

that pyemia may develop with septicemia. It may also develop when there is suppuration in a wound, but not septicemia, no lymphatic absorption of bacteria or toxins having occurred. A suppurating focus about a vein may cause thrombophlebitis and clot-formation even when no wound exists. This is seen in thrombophlebitis of the lateral sinus secondary to suppuration of the middle ear.

A vessel thrombus runs up in the lumen of a vein, and the apex of the clot softens, a portion of it is broken off by the blood-stream and carried as an embolus into the circulation. Many of these poisonous emboli enter into the blood and lodge in some vessels which are too small to transmit them, and at their points of lodgment form *embolic, secondary*, or *metastatic abscesses.* If the embolus contains only pyogenic toxins the danger is infinitely less than if it contains bacteria. The secondary abscess if caused by a clot containing only toxins may not lead to further dissemination of disease. If the embolus contains bacteria, thrombophlebitis occurs about it, and new infected emboli form and are sent throughout the system. Wounds of the superficial parts and bones produce pyemic infarctions and metastatic abscesses of the lungs. When these infarctions break into fragments particles may return to the heart and lodge, or may be sent out through the arterial system to form other foci in distant organs. Infected areas connected with the portal circulation (intestinal injuries or suppurating piles) may produce abscess of the liver. Wounds of bones which open the medullary cavity or diploic structure are particularly apt to be followed by pyemia, and the disease may follow labor, phlegmonous erysipelas, and other conditions. Malignant endocarditis is called "*arterial pyemia*," and is due to endocardial embolic infection. In this disorder infected emboli lodge in the kidneys, the spleen, the alimentary tract, the brain, or the skin (Osler). Idiopathic pyemia is a misnomer. Some primary focus of infection must exist, as was pointed out when discussing septicemia.

Symptoms.—The wound often becomes dry and brown, and sometimes also offensive. A severe and prolonged chill or a succession of chills ushers in the disease; high fever follows, and drenching sweats occur. The chills recur every other day, every day, or oftener. A chill arises from the liberation and lodgment of emboli. During the sweat the temperature falls and may become nearly normal, normal, or actually subnormal. The temperature often oscillates violently. The general symptoms of vomiting, wasting, etc., resemble those of septicemia. In some cases the mind remains clear, in many the delirium is purely nocturnal. The skin frequently becomes jaundiced, and a profound adynamic state is rapidly established. The blood changes are like those of septicemia. The spleen is enlarged. The lodgment of emboli produces symptoms whose nature depends upon the organ involved. Lodgment in the lungs causes shortness of breath and cough, with slight physical signs. Lodgment in the pleura or pericardium gives pronounced physical evidence. Lodgment in the spleen produces severe pain and great enlargement. The parotid gland not unusually suppurates.

In a suspected case of pyemia always examine an existing wound, and if there is no wound, remember that the infection may arise from gonorrhea, osteomyelitis, suppuration in the middle ear, appendicitis, dental caries, tonsillar suppuration, abscess of the prostate, etc. Chronic pyemia may last

for months; acute pyemia may prove fatal in three days. The chief complications are joint-suppuration, bronchopneumonia, pleuritis, empyema, endocarditis, pericarditis, peritonitis, nephritis, cholecystitis, pyelitis, venous thrombosis, and abscesses.

Treatment.—The treatment is the same as for septicemia. Open, drain, and asepticize any wound and any accessible secondary abscess.

XI. ERYSIPELAS (ST. ANTHONY'S FIRE).

Erysipelas is an acute, contagious, spreading capillary lymphangitis due to the streptococci of erysipelas, which grow and multiply in the smaller lymph-channels of the skin and its subcutaneous cellular layers and also in the lymph-channels of serous and mucous membranes. *Cutaneous erysipelas* is characterized by a rapidly spreading dermatitis, by a remittent fever due to absorption of toxins, and by a tendency to recurrence. It is always preceded by a wound, a scratch, or an abrasion, which may have been trivial and may never have been noticed. The so-called idiopathic erysipelas is preceded by a breach of surface continuity so small as to escape notice. The initial point of infection may be in the mouth, the nostril, the pharynx, the auditory meatus, between the fingers or toes, at the margin of a nail, or in a cutaneous furrow. The involved area in cutaneous erysipelas seldom suppurates but sometimes does, very thin or watery pus being formed. If thick pus forms it means mixed infection with staphylococci, but the formation of thin pus does not require a mixed infection, as the streptococcus is identical with the *streptococcus pyogenes.* In some cases of erysipelas, staphylococcus infection follows and even actually replaces streptococcus infection. The rapid spread of erysipelas is due to the fact that the streptococci prevent coagulation of exudate and are not actively attacked by leukocytes. Erysipelas is most common in the spring and fall, and is most usually met with among those who are crowded into dark, dirty, and ill-ventilated quarters; it attacks by preference the debilitated and broken-down (as alcoholics and sufferers from Bright's disease). The disease may become endemic in special places or localities. The poison of erysipelas will produce puerperal fever in a lying-in woman. The streptococcus was first obtained in pure cultures by Fehleisen. This organism is widely diffused. The question of identity with the streptococcus pyogenes is discussed on page 44.

Forms of Erysipelas.—*Ambulant, erratic, migratory,* or *wandering* erysipelas is a form which tends to spread widely over the body, leaving one part and going to another. *Bullous* erysipelas is attended by the formation of bullæ. In *diffused* erysipelas the borders of the inflammation gradually merge into healthy skin. *Erythematous* erysipelas involves the skin superficially. *Metastatic* erysipelas appears successively in various parts of the body. *Puerperal* erysipelas begins in the genitals of lying-in women, producing puerperal fever. *Erysipelas simplex* is the ordinary cutaneous form. *Erysipelas neonatorum* begins in the unhealed navel of a newborn child and spreads from this point. *Typhoid* erysipelas occurs with profound adynamia. *Universal* erysipelas involves the entire body. *Cellulitis* is often erysipelas of the subcutaneous layers. *Phlegmonous* erysipelas involves the skin and the

cellular tissues, and causes suppuration, and often gangrene. *Edematous* erysipelas is a variety of phlegmonous erysipelas with enormous subcutaneous edema. *Lymphatic* erysipelas is characterized by rose-red lines due to lymphangitis. *Venous* erysipelas is marked by the dark color of venous congestion. *Mucous* erysipelas involves a mucous membrane. Erysipelas may attack the fauces, producing the very grave condition known as *faucial* erysipelas.

Clinical Forms.—The clinical forms are cutaneous erysipelas; cellulo-cutaneous or phlegmonous erysipelas; cellulitis, and mucous erysipelas.

Cutaneous erysipelas most frequently attacks the face. A fever suddenly appears, rises rapidly, reaches a considerable height, is remittent in type and sometimes distinctly fluctuating, and usually terminates in four or five days by crisis. At the time of febrile onset spots of redness appear on the skin. These spots run together, and soon a large extent of surface is found to be red and a little elevated. Any wound, ulcer, or abrasion which exists becomes dry and unhealthy, and its edges redden and swell. The erysipelatous area of redness and swelling extends either in spots with intervening healthy skin or in an uninterrupted line. The margin is usually sharply defined from the healthy skin, and the color fades at the original focus as the disease advances at the periphery of the red area. The color fades at once on pressure and returns at once when pressure is removed. There is slight burning pain, which is increased by pressure. In the hyperemic area vesicles or bullæ form, containing first serum and later it may be sero-pus, but there is rarely genuine suppuration in cutaneous erysipelas. Edema affects the subcutaneous tissues, producing great swelling in regions where there is much loose cellular tissue (as in the eyelids). The anatomically related lymphatic glands may become large and tender. In an ordinarily strong person the color of an erysipelatous area is bright red or more rarely dark red. A dusky color precedes suppuration. A blue color precedes gangrene or indicates profound cardiac and pulmonary involvement. Erysipelas spreads now in one direction, now in another, influenced, acccording to Pfleger, by the furrows of the skin. When the disease ceases to spread, the swelling and redness gradually abate, and after they disappear desquamation takes place, and the blebs become dry and crusted.

In strong subjects the constitutional symptoms of cutaneous erysipelas are usually slight. In the old and debilitated the symptoms are typhoidal, there is a dry tongue, dyspnea, and hebetude, delirium comes on, and death is usual. Possible complications are meningitis, pneumonia, septicemia, pleuritis, pyemia, endocarditis, arthritis, and albuminuria. Erysipelas neonatorum is generally fatal. In some instances an attack of erysipelas will cure an old skin eruption, a new growth, an ulcer, or an area of lupus. This is the *érysipèle salutaire* of our French *confrères*.

Treatment.—Isolate the patient, asepticize the wound, if there be a wound, and administer a purge. Cases of cutaneous erysipelas occurring in a fairly healthy, young or middle-aged subject, tend to get well without treatment. If a person is debilitated, free stimulation is necessary. Tincture of chlorid of iron is usually administered in doses of from 20 to 40 ♏ three times a day. Tonic doses of quinin are also given. Nutritious food is given at intervals of three or four hours. For sleeplessness or delirium use chloral or the bromids; for very high temperature, cold sponging is required. To prevent

spreading some have advised injection of the healthy skin near the blush with a 2 per cent. carbolic solution or with fluid containing gr. $\frac{1}{16}$ of corrosive sublimate. A band of iodin painted on the skin may arrest the progress of the disease, and so may a ring streaked around a limb or about an erysipelatous area by lunar caustic. Kraske has suggested a method of preventing the spread of cutaneous erysipelas which is often effective. The patient is anesthetized. At about two inches from the margin of the redness a series of cuts are made into the skin, to a sufficient depth to cause free oozing. Each cut is crossed by another cut and a ring of scarifications is made to surround the region of the erysipelas. After the oozing ceases the scarified area is soaked for one hour with a solution of carbolic acid (1 : 20) or corrosive sublimate (1 : 2000). The part is dressed with pads wet with carbolic acid (1 : 40) or corrosive sublimate (1 : 2000). This operation causes the formation of a protective barrier of leukocytes. Locally, paint the inflamed area with equal parts of iodin and alcohol and apply lead-water and laudanum. The iodin is germicidal and quickly enters the lymph-spaces. The lead-water and laudanum allays the burning pain. If an extremity be involved, bandage it. Some advocate a daily inunction of Credé's soluble silver. A good application is a 50 per cent. ichthyol ointment with lanolin. A very useful method is von Nussbaum's. The author applies it somewhat modified, as follows: wash the part with ethereal soap, irrigate with a solution of corrosive sublimate (1 : 1000), dry with a sterile towel, apply an ointment of ichthyol and lanolin (50 per cent.), and dress with antiseptic gauze. Some use iced-water cloths. Hot fomentations are distinctly harmful. Some apply borated talc or salicylated starch. Ringer advised painting every three hours with a mixture composed of gr. xxx of tannic acid, gr. xxx of camphor, and ʒiv of ether. J. M. DaCosta recommended pilocarpin internally in the beginning of a case. Antistreptococcic serum has been used in erysipelas, and great results have been claimed for it. It is asserted that under its influence the temperature soon becomes normal. My personal experience with the serum treatment has not convinced me of its value, although some cases seem to be benefited.

Cellulocutaneous or **phlegmonous erysipelas** is characterized by high temperature (104°–106° F.), the rapid onset of grave prostration, irregular chills, sweats, and a strong tendency to delirium. The constitutional condition may be one of suppurative fever, sapremia, septicemia, or pyemia. The parts are red, as in cutaneous erysipelas, and the tumefaction is vastly greater. The swelling is brawny, comes on early, increases with exceeding rapidity, induces a high degree of tension, and frequently becomes associated with sloughing or even cutaneous gangrene. The lymphatic glands are swollen, but the inflamed lymphatic vessels are hidden by the tumefaction. In most cases suppuration occurs, and when this happens the parts become boggy and the pus is widely disseminated in the subcutaneous and intramuscular tissues, and even into muscle-sheaths and tendon-sheaths (purulent infiltration). When the disease abates sloughs form, which leave ulcers upon being cast off. In bad cases muscles, vessels, tendons, and fascia may slough away. The commonest complications are suppression of urine, bronchopneumonia, congestion and edema of the lungs, meningitis, congestion of the kidneys, and acute pleurisy. Septicemia or pyemia may occur. We sometimes meet with

this form of erysipelas after extravasation of urine. It is not a pure streptococcus infection. There is a mixed infection with other pyogenic cocci, and often with organisms of putrefaction.

Treatment.—At once asepticize and drain any existing wound, and dress such a wound with hot antiseptic fomentations. If there are inflamed lymph-vessels or glands above the area of cellulocutaneous infection, paint the skin above them with iodin and smear it with blue ointment or rub in Credé's ointment of soluble silver. Make numerous incisions into the inflamed tissues. These incisions should be near together, and each cut should be two or three inches long. Spray the wounds with hydrogen peroxid by means of an atomizer, wash with corrosive sublimate solution (1 : 1000), and pack each wound with iodoform gauze. Dress with many layers of gauze wet with a hot solution of corrosive sublimate. The gauze is covered with a rubber dam and a hot-water bag is laid upon the dressing. If sloughs form, cut them away and employ hot antiseptic fomentations. Change the dressings often. In

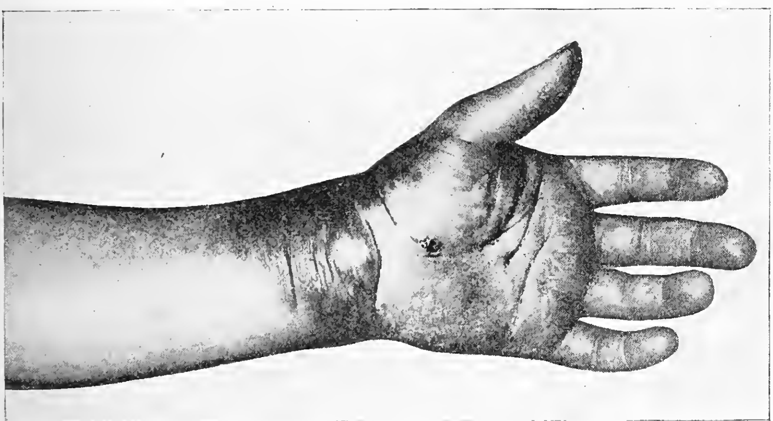


Fig. 88.—Acute cellulitis of palm and forearm following a slight wound.

some cases it may be necessary to employ continuous irrigation with warm antiseptic fluid, or continuous immersion in a hot aseptic or antiseptic bath. It is not unusually necessary to operate for the removal of enlarged lymphatic glands. In rare cases amputation is demanded. When granulations begin to form, treat as a healing wound. The constitutional treatment is that previously set forth as applicable to septicemia, viz., purgation, the use of diuretics and diaphoretics, the administration of strychnin, quinin, digitalis, alcoholic stimulants, and nourishing food. Antistreptococcic serum may be employed. In severe cases employ hypodermoclysis or saline infusion into a vein.

Cellulitis.—Cellulitis (Fig. 88) is a microbic inflammation of the cellular tissue. It may be due to staphylococci, to streptococci, to other pyogenic bacteria, or to mixed infection with two varieties of pyogenic organisms. The commonest form is streptococcus infection, and this is a variety of erysipelas. A streptococcus infection may be followed and replaced by a staphylococcus infection. Infection with the *bacillus aërogenes capsulatus* causes *gangrenous cellulitis.* Cellulitis is prone to arise in damaged tissues, for instance, in

a crushed part, a limb the seat of a compound fracture, or tissue containing extravasated urine. In tissue the resistance of which has been lessened by diabetes, Bright's disease, irritating discharges, or trophic lesions, cellulitis is rather apt to develop. In cellulitis of the subcutaneous tissue the microorganisms find entrance by means of a wound. Swelling precedes redness. The swelling is not so marked as in phlegmonous erysipelas, and the redness is darker and is less distinct than in cutaneous erysipelas. The redness of cellulitis is about the wound; it spreads but does not fade at the center as does ordinary erysipelas; red lines due to lymphangitis ascend the limb from the infected wound, and the anatomically associated lymphatic glands enlarge. In the wound and its neighborhood there is severe throbbing pain. The constitutional symptoms of infection develop rapidly. In trivial cases the lymphatics dispose of the poison and suppuration does not occur. In severe cases pus forms about the wound and lymphatic glands may suppurate. Phlegmonous erysipelas may develop, and septicemia or pyemia may arise.

Treatment.—Open, disinfect, and drain the wound. Paint iodin upon the skin over inflamed lymphatic vessels and glands and cover with ichthyol ointment or rub Credé's soluble silver ointment into the skin over the inflamed lymph-glands and vessels. Dress the wound and the adjacent inflamed area with hot antiseptic fomentations. Secure rest of the part. It may be necessary to make incisions as in phlegmonous erysipelas. In some cases it is necessary to remove breaking-down glands. The constitutional treatment is that employed for septicemia.

XII. TETANUS, OR LOCKJAW.

Tetanus is a microbic disease invariably preceded by some injury and characterized by spasm of the voluntary muscles. The wound may have been severe, it may have been so slight as to have attracted no attention, it may have been inflicted upon the alimentary canal by a fish-bone or other foreign body, or may have been situated in the nose, urethra, vagina, or ear. It is possible that infection can occur through a mere abrasion of a mucous membrane. The so-called idiopathic tetanus is either not tetanus at all, or the term expresses the fact that we have not found the traces of an injury which did exist. Tetanus arises most frequently after punctured and particularly after lacerated wounds of the hands or feet. In a surgical experience of twenty years in connection with the Philadelphia Fire Department I have known hundreds of firemen to injure their feet by stepping on nails and not one developed tetanus. In fact, the only case of tetanus among them since 1871 arose in a man who lacerated his hand with glass. Before tetanus appears a wound is apt to suppurate or slough; but in some instances the wound is found soundly healed when the tetanus begins. The toy pistol produces a peculiarly dangerous wound. In the United States many cases of tetanus follow the celebration of the Fourth of July, a large per cent. of the causative wounds being from the toy pistol. The Fourth of July, 1903, was responsible for 466 reported and no one knows for how many unreported cases in the United States. The fact that the bacillus of tetanus is anaërobic explains the comparative frequency with which punctured and lacerated wounds are attacked, for in such wounds the bacilli are deeply

lodged in recesses or cavities into which air does not penetrate or are covered with discharges which exclude air. Suppuration favors the growth of tetanus bacilli, because the pyogenic organisms consume oxygen. Occasionally, though fortunately very rarely, tetanus follows vaccination. It is essential that vaccine virus should be carefully selected and prepared. When care is taken, the operation is absolutely safe. When tetanus follows vaccination, it arises from infection of the wound either at the time of vaccination or, as is common, at a later period from scratching or some other fouling. Tetanus has followed the injection of gelatin. Commercial gelatin often contains the bacilli and should never be used without careful fractional sterilization (page 363). Tetanus may appear within twenty-four hours after an accident, but it may not arise until many days or even several weeks have elapsed. Rose reported a case which began within twenty-four hours. Kuhn ("Berliner klinische Wochensch.," 1901) reports a fatal case of tetanus beginning twelve hours after an injection of gelatin. Such a rapid case could only be due to the gelatin having contained a large quantity of tetanus toxin (Schuckmann). Samuel D. Gross, in his "System of Surgery," speaks of one case occurring in a man five weeks after injury, and another in a girl four weeks after injury. Jacobson and Pease are of the opinion that "such cases as have been recorded with periods of incubation under three days must be accepted with considerable reserve" ("Annals of Surgery," Sept., 1906). Tetanus prevails more in certain localities than in others. Colored people are very susceptible, and the disease may exist endemically, and does so in certain portions of New Jersey and of Cuba. In our country the greatest prevalence, according to Anders, is in Pennsylvania, Northern New York, Long Island, Virginià, Georgia, and Louisiana. Anders collected 1201 cases and Pennsylvania stands first on his list with 224 cases ("Jour. Am. Med. Assoc.," July 29, 1905). Tetanus is due to the growth in a wound of a bacillus which was first described by Nicolaier and was first cultivated by Kitasato. It is the most widely distributed of all the pathogenic bacteria. It is very difficult to cultivate and cannot be cultivated at all unless air is absolutely excluded. Tetanus bacilli or their spores are found particularly in garden soil, in the dust of walls, walks, and cellars, in street dirt, and in the refuse of stables. There is much suggestive evidence that virulent tetanus bacilli come from the intestinal canal of animals; that the bacteria lose their virulence when long outside of the intestinal canal; and that the highest degree of virulence is obtained by those which have passed frequently through intestinal canals. The above view is known as the fecal theory and is strongly advocated by Somani.*

In tetanus the bacilli do not enter into the blood and toxic products produced by them are not directly absorbed by the blood or lymph. The toxic products alone without any bacteria enter the muscular end organs of motor nerves, ascend within the nerves and reach the spinal cord and medulla (Brunner, Marie), become fixed in the nerve-cells of the spinal cord and medulla, and produce the symptoms of the disease. Hence tetanus is an intoxication and not an infection, and a drop of blood of an animal with tetanus, if injected into another animal, will not produce the disease. Tetanus toxin poisons the nervous system as would strychnia or some other vegetable alkaloid. It is probably the most powerful of known

* "Verhandl. d. 10. internat. med. Cong.," Berlin, 1890, Bd. v, Abth. 15, p. 152.

poisons. It has been estimated that $\frac{1}{278}$ of a grain is sufficient to kill an adult weighing 165 pounds ("American Medicine," Nov. 30, 1901). The great power of the poison is shown by the report of Dr. Nicholas's case ("Comptes rendu de la Société de Biologie," 1893). Dr. Nicholas had been using a syringe to inject filtered cultures of the bacilli of tetanus and he accidentally pricked his finger with the needle. In four days tetanus began, and the Doctor barely escaped with his life in spite of the fact that the fluid was free of bacteria and the dose of toxin was extremely minute. The nature of the virulent poison which is produced at the seat of inoculation is uncertain. Some believe it to be alkaloidal, like the vegetable alkaloids; some that it is a toxalbumin, others maintain that it is an enzyme or ferment (Nocard, Courmont, and others). In a very few instances the injection of perfectly sterile antidiphtheritic serum into human beings has caused death with all the symptoms of tetanus. The serum must have been obtained from horses in whom tetanus was incubating, and the blood-serum injected must have contained a fatal dose of tetanus toxin. In tetanus an ascending neuritis occasionally, though seldom, exists in the peripheral nerve near the lesion. The toxin is carried to the cord by the motor nerves only, and it is not only absorbed by the lymph-channels of the nerve but ascends along the axis-cylinders of the nerve itself and reaches the motor cells of the spinal cord (Meyer and Ransom, in "Arch. exper. Path. u. Pharmakol.," 1903). On reaching the cord it attacks the motor nerve-cells, producing changes similar to those involved in certain infections, and ascends in the motor tracts of the cord to the medullary nerve-centers. While toxin is ascending the axis-cylinders a certain amount is taken up by the lymphatics, enters the blood, and reaches the spinal cord by other nerve-fibers (Jacobson and Pease, in "Annals of Surgery," Sept., 1906). The essential basis of tetanus is spreading irritation of the motor portion of the spinal cord accompanied by extreme reflex excitability which is due to poisoning of sensory neurones (Meyer and Ransom). The irritation of the motor cord produces tonic contraction of the muscles; the excitation of the sensory neurones is responsible for clonic convulsions.

Local Tetanus.—In some cases local symptoms precede widespread evidences of tetanus. Experimental tetanus in animals "exhibits almost without exception as its earliest manifestations those of a purely local character and which are at first restricted to the neighborhood of the inoculation. This is now understood to be due to the absorption of the toxin by the motor-nerve of the part. The conditions favoring the local appearance of tetanus are a short motor nerve as in head injuries; an injury to a nerve-trunk permitting the rapid absorption of a large amount of toxin; the production of a meager amount of toxin or the presence of something which prevents the admission of a large amount of toxin into the circulation (Nathan Jacobson and Herbert D. Pease, in "Annals of Surgery," Sept., 1906). Cases with local symptoms in the beginning are apt to have had long periods of incubation, are apt to be cured, and usually endure a considerable time.

Symptoms.—**Acute tetanus** begins within ten days of an accident. The usual period of incubation is from three to five days. In most cases the first symptom is stiffness of the jaw on opening the mouth. In some cases the first symptom is stiffness of the neck, and the patient believes he has "caught cold." In any case the neck soon becomes stiff, and finally both

the neck and jaw become as rigid almost as iron. The fixation of the jaw is called *trismus*. The muscles of deglutition become rigid on attempts at swallowing. The muscles of the back, legs, and abdomen are thrown into tonic spasm, but the arms rarely suffer. If the infected injury is on the hand or foot, that extremity usually is found to be rigid. Spasm of the face muscles causes the *risus sardonicus*, or sardonic smile (contraction particularly of the *musculus sardonicus* of Santorini). The contraction of the muscles of the back is often so powerful as to bend the patient into a curve like a bow and allow him to rest only on his occiput and heels. This condition is known as *opisthotonos*. If he is bent forward, so that the face is drawn to the legs, it is called *emprosthotonos*. If his body is curved sideways, it is designated *pleurosthotonos*. An upright position is *orthotonos*. The spasm may be so violent as to cause muscular rupture.

The characteristic condition in tetanus is one of widely diffused tonic spasm, aggravated frequently by clonic spasms arising from peripheral irritations. These irritations may be draughts, sounds, lights, shaking of the bed, attempts at swallowing, contact of the bed-clothing, the presence of urine in the bladder or of feces in the rectum, or various visceral actions. The clonic spasms begin early in the case and become more frequent and more violent as the disease progresses. The muscles become more rigid and the attitude produced by the tonic contraction of the muscles is temporarily exaggerated. The forcible contraction of the jaw may loosen or break teeth. The spasms of the diaphragm, of the glottis, and of the muscles of respiration may produce death and always produce great dyspnea. The man laboring under a tetanic convulsion presents a dreadful picture; he is bent into some unnatural attitude, the face is cyanotic and wet with drops of sweat, the lips are covered with froth which is often bloody, the eyes bulge and are suffused, and the countenance expresses deadly terror and suffering. The agonizing "girdle pain" so often met with is due to spasm of the diaphragm. Each clonic spasm causes a hideous scream by the constriction of the chest forcing air through a contracted glottis. During the progress of the disease constipation is persistent, and retention of urine is the rule (because of sphincter spasm). The mind is entirely clear until near the end—one of the worst elements of the disease. Swallowing in many cases is impossible. Talking is very difficult and it is impossible to project the tongue. The muscles throughout the body feel very sore. The temperature may be normal, but it is usually a little elevated, and always rises just before death. Hyperpyrexia sometimes occurs (108°–110° F.), and the temperature may even ascend for a time after death. Insomnia is obstinate. In between 80 and 90 per cent. of cases of acute tetanus death occurs within five days, and many of these patients die within two or three days. Of late years the mortality in acute tetanus has slightly diminished. If a patient lives a week, his chance of recovery is good. Death may be due to exhaustion or to carbonic-acid narcosis from spasm of the glottis or fixation of the respiratory muscles.

Chronic tetanus comes on late after a wound (from ten days to several weeks). The symptoms are not so severe as in acute tetanus. The muscular spasm is widespread, but it may not be persistent, intervals of relaxation permitting sleep and the taking of food. Chronic tetanus long had a mortality of 40 or 50 per cent., but modern methods of treatment, it has been

claimed, have considerably reduced it. According to the report of Jacobson and Pease it is still from 35 to 50 per cent. ("Annals of Surgery," Sept., 1906). The disease may last for some weeks. *Trismus neonatorum*, or *trismus nascentium*, the lockjaw of the newborn, is due to infection of the stump of the umbilical cord, and is practically invariably fatal. *Hydrophobic tetanus*, *head tetanus*, or *cephalic tetanus*, is a condition in which the spasms are confined chiefly to the face, pharynx, and neck, although the abdominal muscles are usually also rigid, and in which there is palsy of the seventh nerve. It follows head-injuries, and gives a better prognosis than does general tetanus.

Two other forms of tetanus have been produced in animals by experimenters. One is *cerebral tetanus*, produced by injecting tetanus toxin into the brain and characterized by mental symptoms (Roux and Borrell, in "Annals Ins. Pasteur," July, 1897). Another is *tetanus dolorosa*, produced by injecting toxin into the posterior roots of the spinal nerves, and characterized by violent spasms of pain without motor symptoms.

Diagnosis.—Tetanus may be confounded with strychnin-poisoning, with hysteria, with tetany, or with hydrophobia. Wood's table makes the diagnosis clear between tetanus, strychnin-poisoning, and hysteria.*

Tetanus.	Hysterical Tetanus.	Strychnin-poisoning.
	Commences with blindness and weakness.	Begins with exhilaration and restlessness, the special senses being usually much sharpened. Dimness of vision may in some cases be manifested later, after the development of other symptoms, but even then it is rare.
Muscular symptoms usually commence with pain and stiffness in the back of the neck, sometimes with slight muscular twitching; comes on gradually. Jaw one of the earliest parts affected; rigidly and persistently set.	Muscular symptoms commence with rigidity of the neck, which creeps over the body, affecting the extremities last. Jaws rigidly set before a convulsion, and remain so between the paroxysms.	Muscular symptoms develop very rapidly, commencing in the extremities, or the convulsion when the dose is large seizes the whole body simultaneously. Jaw the last part of the body to be affected; its muscles relax first, and even when, during a severe convulsion, it is set, it drops as soon as the latter ceases.
Persistent muscular rigidity very generally, with a greater or less degree of permanent opisthotonos, emprosthotonos, pleurosthotonos, or orthotonos.	Persistent opisthotonos and intense rigidity between the convulsions and after the convulsions have ceased, the opisthotonos and intense rigidity lasting for hours.	Muscular relaxation (rarely a slight rigidity) between the convulsions, the patient being exhausted and sweating. If recovery occurs, the convulsions gradually cease, leaving merely muscular soreness, and sometimes stiffness like that felt after violent exercise.
Consciousness preserved until near death, as in strychnin-poisoning.	Consciousness lost as the second convulsion comes on, and lost with every other convulsion, the disturbance of consciousness and motility being simultaneous.	Consciousness always preserved during convulsions, except when the latter become so intense that death is imminent from suffocation, in which case sometimes the patient becomes insensible from asphyxia, which comes on during the latter part of a convulsion and is almost a certain precursor of death.

* "Nervous Diseases," by Prof. H. C. Wood.

Tetanus.	Hysterical Tetanus.	Strychnin-poisoning.
Draughts, loud noises, etc., produce convulsions, as in strychnin-poisoning; may complain bitterly of pain.	Crying spells alternating with convulsions.	The "slightest breath of air" produces convulsion. Patient may scream with pain or may express great apprehension, but "crying spells" would appear to be impossible.
Eyes open and rigidly fixed during the convulsion.	Eyes closed.	Eyes stretched wide open.
	Partial spasm in the leg, producing in Wood's cases crossing of the feet and inversion of the toes. If all the muscles were involved, eversion would occur, as the muscles of eversion are the stronger.	Legs stiffly extended with feet everted, as the spasms affect all the muscles of the leg.

Tetany is distinguished from tetanus by the milder nature of the spasms, by the greater limitation of the rigidity, by the fact that spasms begin in the hands or feet, not in the jaw and neck, and in most cases by periods of distinct intermittence.

In hydrophobia tonic spasm does not exist, and if clonic spasms occur they are secondary to suffocative attacks.

Treatment.—Far better even than to treat tetanus well is to prevent it. Careful antisepsis will banish it as a sequence of surgical operations as thoroughly as it has banished septicemia. Every infected wound must be disinfected with the most scrupulous care. Every punctured wound is to be incised to its depths and thoroughly cleaned and drained. In a very suspicious wound, such as a Fourth of July injury or a wound from a dung fork, or the entrance into the tissues of a splinter from a stable floor, after the removal of foreign bodies and thorough antiseptic cleansing, dust the wound with antitoxin powder (McFarland) or give antitoxin hypodermatically. It seems reasonably certain that tetanus antitoxin has prophylactic power, in fact, Jacobson and Pease say that, "as a prophylactive measure it merits our fullest confidence" ("Annals of Surgery," Sept., 1906). Obviously, this cannot be done for every wound. The procedure is not a certain preventative. Reynier injected antitoxin into a patient on whom he was about to operate because there was a case of tetanus in the wards and yet this man developed tetanus ("Gaz. des Hôpitaux," July 16, 1901). Nevertheless it is sure that animals can be rendered immune to tetanus, and the prophylactic power of antitoxin is warmly advocated by many eminent men. (See F. L. Taylor, in "N. Y. Med. Journal," July 20, 1901.) Puerperal tetanus is prevented by antiseptic midwifery, and tetanus neonatorum is obviated by the antiseptic treatment of the stump of the cord. In order to obviate all danger of the development of tetanus during vaccinia, perform the little operation with cleanliness and care properly for the wound and for the pustule. The skin should be cleansed with soap and water, rubbed with alcohol, and washed with boiled water. It should be gently scraped with a knife (which has been boiled) until serum exudes. The virus, taken from a hermetically sealed tube, is applied to the raw surface, and allowed to remain exposed to

the air until dry. A piece of sterile gauze is laid over the part and is held in place by a bandage. This dressing is changed once or twice a day as may be necessary, and is used until granulation begins, at which time the use of any simple ointment is admissible. Do not apply a shield. The evil of shields is pointed out by Robert N. Willson ("American Medicine," Dec. 7, 1901).

When tetanus exists, always look for a wound, and if one is found, open it; if there are sloughs, cut them away, wash the wound with peroxid of hydrogen and then with hot normal salt solution, dry the wound with gauze, paint the surfaces of the wound with bromin, and secure drainage by packing with iodoform gauze. Dennis disinfects the wound with a solution of trichlorid of iodin (0.5 per cent.).

Surgeons of a former day were accustomed to amputate for tetanus if the wound was upon an extremity. When we reflect that the poison-producers are in the wound and not in the circulation, it seems a reasonable treatment. As a matter of fact, it never does any good, because, when the symptoms begin, the toxin has already entered into the nerve-cells and become fixed. Kitasato has shown that if a mouse is inoculated with tetanus near the root of the tail, excision of the tail and cauterization of the stump will not prevent tetanus unless it is performed within one hour of the inoculation; and Nocard inoculated sheep near the root of the tail with tetanus spores, and although the moment symptoms appeared he amputated well above the point of inoculation, the animals died of the disease. We must regard amputation as a useless method of treatment.

Keep the sufferer from tetanus in a darkened, well-ventilated, and quiet apartment, so as to exclude as far as possible peripheral irritation. Watch for the occurrence of retention of urine, and use the catheter if necessary. Secure movements of the bowels by administering salines, castor oil, croton oil, or enemas. Stimulate freely with alcohol. Give plenty of concentrated liquid food unless swallowing causes convulsions, then feed by the rectum, and give fluids by hypodermoclysis. If swallowing causes convulsions some surgeons give an inhalation of nitrite of amyl before an attempt is made to swallow. If this treatment does not make swallowing possible then partially anesthetize the patient and feed him by means of a pharyngeal tube passed through the nose. Better than either of these plans is to abandon mouth feeding. Large doses of the bromid of potassium, or of this drug with chloral, give the best results, as far as drug treatment is capable of giving results. If bromid is used, give about ʒj every four to six hours. Other drugs that have been used with some success are gelsemium, morphin, curare, injections and fomentations of tobacco, physostigmin, anesthetics, cocain, and cannabis indica. An ice-bag to the spine somewhat relieves the girdle pain. Hot baths have been advised. It is said that venesection followed by the intravenous infusion of saline fluid does good. This procedure is followed by a free flow of urine and by lessening of the number of the paroxysms. It may be repeated several times during a few days (E. J. McOscar, in "American Medicine," Sept. 14, 1901; A. V. Moschcowitz, in "Med. News," Oct. 13, 1900).

Yandell says, in summing up Cowling's report on tetanus:* "Recoveries from traumatic tetanus have been usually in cases in which the disease occurs subsequent to nine days after the injury. When the symptoms last fourteen

* American Practitioner, Sept., 1870.

days, recovery is the rule, apparently independent of treatment. The true test of a remedy is its influence on the history of the disease. Does it cure cases in which the disease has set in previous to the ninth day? Does it fail in cases whose duration exceeds fourteen days? No agent tried by these tests has yet established its claims as a true remedy for tetanus."*

It is now claimed by some observers that we have a remedy which fulfils the requirements of Yandell in the tetanus antitoxin serum. Behring's serum is said to be six times as strong as Tizzoni's, but it is difficult or impossible to estimate the exact power of either. Behring and Kitasato succeeded in immunizing animals and Tizzoni and Cattani discovered that the antitoxin is an enzyme. The antitoxin destroys the activity of the toxin and is obtained from an immunized horse.

If injected subcutaneously it is absorbed very slowly and even twenty-four hours or more after such an injection a considerable amount remains unabsorbed in the tissues. It is not absorbed at all by the nervous structures. It is eliminated rapidly and unaltered in the urine, feces, and sweat. It seems to be harmless and its immunizing powers are certain. Its curative power is very much less active. Hypodermatic injections are practically useless. Intravenous injections are of more service, but even then the antitoxin only grasps the toxin in the blood and fails to reach that in the nerves, nerve-cells, and nerve tracts. Some practice intramuscular injections, but 7 acute cases so treated died, a mortality of 100 per cent. (Jacobson and Pease, "Annals of Surgery," Sept., 1906). Injection into the theca of the cord (intraspinal injection) by means of lumbar puncture is an attractive method but the inability of nerve-elements to absorb antitoxins when the pia intervenes, is an argument against it, though in one violent acute case of my own, occurring in a boy, recovery followed this method. In 7 acute cases treated by this method the mortality was 57.1 per cent. (Jacobson and Pease, in "Annals of Surgery," Sept., 1906). John Rodgers injected antitoxin into the cauda equina and nerves and cured two apparently hopeless cases ("Med. Record," July 2, 1904). Injection into a nerve (intraneural injection) is a more rational method, but even this plan is only of service in localized tetanus, the main nerve above the part tetanized being injected (Küster, in German Surgical Congress of 1905). However antitoxin is given the dose must be large if any good is to be done. Serum is usually prepared as follows: A horse is injected repeatedly with the toxins obtained from cultures of tetanus bacilli, the strength of the injections being gradually increased. Eventually the animal becomes immune to tetanus. Some days after the final injection a cannula is placed in the jugular vein of the immunized animal, blood is drawn into a sterile vessel and is permitted to coagulate during twenty-four hours, and at the end of this period the serum is separated from the clot, is evaporated to dryness in a vacuum over sulphuric acid, and the powder is placed in hermetically sealed glass tubes. In order to use the serum, dissolve the powder in sterile water, in the proportion of 1 gm. to 10 c.c. The fluid serum sold in the shops bears this proportion to the powder. The serum can be given subcutaneously or intravenously, or can be injected into the brain or under the cerebral dura or the spinal arachnoid, or into a nerve. If used subcutaneously, from 20 to 30 c.c. of the fluid serum should be injected into the abdominal wall, and this dose should

* Quoted by Hammond, in his "Diseases of the Nervous System."

be given every six or eight hours until there is improvement. Then from 5 to 10 c.c. should be given every six or eight hours. As the symptoms abate the dose is lessened and the intervals between the doses are increased. In a violent case of tetanus the first dose should consist of 40 to 50 c.c., and this can be repeated in four or five hours. In a case of tetanus which recovered, reported by Mixter, enormous doses were given. This patient received in the aggregate 3400 c.c. of serum, or 285 c.c. a day.* In 47 acute cases treated by subcutaneous injection the mortality was 82.6 per cent. In 30 acute cases treated by a combination of either subcutaneous, intraspinal, intravenous, or intracranial injections the mortality was 93.1 per cent. (Jacobson and Pease, in "Annals of Surgery," Sept., 1906). Roux and Borrel maintain that the toxins of tetanus pass from the blood into nervous tissue and are fixed in the nerve-cells. As the antitoxin when given hypodermatically or intravenously remains in the blood, it can only antidote the poison in the blood and not that in the nerve-cells. These observers advise that the antitoxin be placed where the toxins are active—that is, that it be thrown into the cerebrum (intracerebral injections). The skull is trephined or opened with a small drill, a blunt needle is passed to the depth of one and a half inches into the frontal lobe, and the serum is slowly injected. Abbe follows Kocher; uses a local anesthetic and bores a very small hole through the skull midway between the outer angle of the orbit and the middle of a line running across the head from one external auditory meatus to the other. The serum should be concentrated. One gram of dry antitoxin is dissolved in 5 c.c. of water, and this amount is the proper dose. The opposite frontal lobe should also be injected either at once or the next day. Even when serum has been injected into the cerebrum it should also be given subcutaneously. Abbe employed intracerebral injection in 5 severe cases and 3 of them recovered. He is a strong believer in the method ("Annals of Surgery," March, 1900). Moschcowitz has collected 38 cases so treated and claims that one-half of them recovered. Cerebral abscess followed in 1 case ("Med. News," Oct. 13, 1900). Tuffier has reported a successful case in which he injected 10 c.c. of serum into each frontal lobe ("Gaz. heb. de Med. et Chir.," July 4, 1901). The method has of late been practically abandoned in spite of the early favorable reports.

The value of the tetanus antitoxin in acute tetanus is more than doubtful. Under its use the mortality from acute tetanus is said to fall from nearly 90 per cent. to 75 per cent., but the figures above given do not sustain this contention. Neither do the figures indicate that the mortality in chronic tetanus has been greatly influenced by it. Kitasato has shown that injections of iodoform render animals immune, and Sonnani has maintained that this drug placed in a wound prevents the disease. If antitoxin is not obtainable, give hypodermatic injections of iodoform, 3 to 5 grs. *t. i. d.*

Bacelli's treatment consists in the hypodermatic injection of carbolic acid, which is thought to grasp tetanus toxin and mitigate it or even make it inert. The dose is 15 ♏ of a 3 per cent. solution every two hours. Favorable results are claimed for the plan.

The hypodermatic injection of an emulsion of fresh brain-matter has been advocated on the ground that brain-matter and tetanus toxin have a mutual affinity (Krokiewicz). The results are not conclusive.

* Boston Med. and Surg. Jour., Oct. 6, 1898.

Mathews reports cure in 2 cases following the very gradual introduction into a vein of a solution containing sodium chlorid, sodium citrate, sodium sulphate, and chlorid of calcium ("Jour. Am. Med. Assoc.," August 29, 1903). Cure of acute tetanus has followed the intraspinal injection of a solution of magnesium sulphate (see page 1051). Blake has reported such a case ("Jour. of Surgery, Gynecology, and Obstetrics," May, 1906). It has been shown that a solution of magnesium sulphate strongly stimulates inhibition (Meltzer).

Murphy reports the cure of a case by spinal puncture and injection of morphin and eucain into the theca of the cord ("Jour. Am. Med. Assoc.," August 13, 1904).

XIII. SURGICAL TUBERCULOSIS.

TUBERCULOSIS is an infective disease due to the deposition and multiplication of tubercle bacilli in the tissues of the body. The term *surgical tuberculosis* is applied to all of those numerous tuberculous lesions that demand surgical treatment. Such lesions may exist in different structures, are often strictly localized processes, and in many instances may be extirpated, drained, or sterilized. Tuberculosis is characterized either by the formation of tubercles or by widespread cellular proliferation (diffuse tubercle) or by fibrinous exudation which is very rich in cells. Tuberculous conditions tend to caseation, sclerosis, or ulceration.

A *tubercle* is a non-vascular infective focus, appearing to the unaided vision as a semi-transparent gray or yellowish mass the size of a mustard-seed. The microscopic tubercle is the most characteristic evidence of the disease. The microscope shows that a gray tubercle consists of a number of cell-clusters, each cluster constituting a *primitive tubercle*. A typical primitive tubercle shows a center consisting of one or of several polynucleated giant-cells surrounded by a zone of epithelioid cells which are surrounded by an area of lymphocytes. When the bacillus obtains a lodgment the fixed connective-tissue cells multiply by karyokinesis, forming a mass of nucleated polygonal or round cells. These cells are connective-tissue cells and derived particularly from endothelium and are called *epithelioid cells* from their resemblance to epithelial cells. Early in the development of a tubercle blood channels lined with epithelioid cells exist, but continued cell proliferation blocks the channels and at the same time the blood-supply of the growth is further limited by the pressure of proliferating perivascular cells and the proliferation of the endothelial cells of adjacent vessels. Some of the epithelioid cells proliferate, and others attempt to, but fail for want of blood-supply. Those which fail to multiply succeed only in dividing their nuclei and enormously increasing their bulk (giant-cells). Giant-cells, which may also form by a coalescence of epithelioid cells, are not always present. Giant-cells are not certain evidence of tuberculosis for they occur in syphilitic lesions. The presence

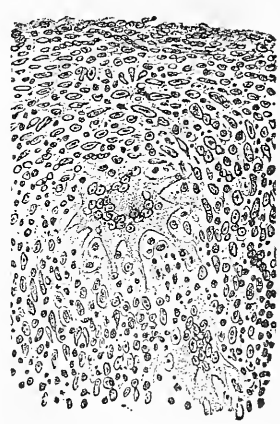


Fig. 89.—Synovial membrane, showing giant-cells (Bowlby).

of irritant bacterial products induces surrounding inflammation and numbers of leukocytes gather about the epithelioid cells (Fig. 89).

The bacilli, when found, exist in and about the epithelioid cells, and sometimes in the giant-cells. When bacilli enter the tissues they are often killed. If they enter in large numbers or are peculiarly virulent they induce chronic inflammation, granulation tissue forms, and the cells of the focus often have the characteristic arrangement described above. The bacilli are not pyogenic and suppuration means secondary infection. A tuberculous focus tends strongly to degenerative changes because of the local anemia and the presence of bacilli. If numerous active bacilli are present *caseation* takes place. This is coagulation necrosis due to the action of bacteria upon a non-vascular area. It starts at the center of a tuberculous focus and spreads toward the periphery and finally forms masses like cheese. When caseated material is mixed with serum *tuberculous pus* is formed.

A caseated focus may be surrounded or encapsuled by fibrous tissue. When this happens the tuberculous process may remain latent for months or years, perhaps awakening into activity as the result of a traumatism or lowered general resistance. A caseated focus may be cured by growth of fibrous tissue which replaces the tuberculous focus. This is cure by sclerosis. A caseated area may calcify. Even when tuberculous pus forms encapsulation may occur, the fluid being absorbed, and the remains being surrounded by fibrous tissue. Whenever tubercle bacilli consume all available food they die or remain latent. If they die the granulations are converted into fibrous tissue and the part is healed. If they remain latent they may at any time become again active. Infiltrated tubercle is due to the running together of many minute infective foci, or to widespread infiltration without any formation of foci. Infiltrated tubercle tends strongly to caseate. The description of a tubercle previously given relates to the common *reticulated tubercle.* Two other varieties exist.

The *fibrous tubercle* is much richer in dense connective tissue than is the ordinary tubercle. It forms when bacilli are greatly weakened or killed. When this happens embryonal cells cease to degenerate, and ordinary inflammation results in fibrous tissue formation. Fibrous tubercle is evidence of an effort at cure.

Hyaline tubercle results from hyaline degeneration of the reticulum of an ordinary tubercle and is the early stage of coagulation necrosis.

The Incidence of Tuberculosis.—Tuberculosis is the most widespread of diseases, being particularly common in northern countries, in civilized regions, and in great cities. Both men and domestic animals suffer from it, and it is occasionally met with in captive wild animals. It may even occur in cold-blooded animals. It is rare in savage races and extremely rare in wild animals dwelling under natural conditions.

How many persons die of tuberculosis is a much debated point. Some writers claim that consumption of the lungs alone kills one-third of all that die; and if the deaths from various other tuberculous lesions are added to this, it will be seen what an enormous part the disease plays in the mortality tables. Many observers hold that one-third of the human race suffer with tuberculosis, and that in every country the remaining two-thirds free from the disease are every moment in danger of acquiring it. Evans has main-

tained that of the 35,000,000 deaths that occur yearly in the world, 5,000,000 are the result of tuberculosis. Pflügge thinks that one-seventh of the race die of tuberculosis.

This enormous incidence of the disease, however, is disputed by some authorities; notably, by G. Cornet (Nothnagel's "Encyclopedia of Practical Medicine"). This distinguished observer states that one-seventh of all deaths result from tuberculosis, and that some pathologists have reported that in one-third of all necropsies tuberculous lesions are found; but that these statistics are obtained from institutions where only the very poor are cared for, and that the percentage of tuberculosis is vastly lower in the better classes of the community. The exact figures, however, are hard to determine. It is certain that enormous numbers of people are affected with tuberculosis. I believe many affected ones recover, for Naegeli points out that almost all who perish after thirty from non-tuberculous conditions show healed lesions of tubercle. Von Behring maintains that all of us are "a little tuberculous" (Jonathan Wright, in "New York Med. Jour.," April 2, 1904). Pflügge maintains that from 50 to 70 per cent. of the human race are predisposed to tuberculous infection and if infected would die of it unless an intercurrent malady destroyed them.

The Bacillus of Tuberculosis.—The tubercle bacillus was discovered by Robert Koch in 1882. It is a little rod with a length about equal to one-half the diameter of a red corpuscle. It does not form spores. Tubercle bacilli exist in all active lesions and the more active the process the greater their numbers. They may be widely distributed throughout the body, and are occasionally, though very seldom, identified in the blood. They may not be found in a tuberculous area, having once existed but died out for want of nourishment. For instance, in a cold abscess they are frequently absent. Bacilli may be destroyed by a secondary infection, for example, by a pyogenic infection. Even when present tubercle bacilli may be overlooked. Differential staining may exhibit the bacilli. In the material from an active tuberculous lesion, even if bacilli are not found, injection of the tuberculous matter into a guinea-pig will be followed by the production of the disease and in these lesions bacilli can be demonstrated. We have discussed the tubercle bacillus on page 46. The bacillus of leprosy, the smegma bacillus, and the tubercle bacillus are similar, but not identical. Each is an acid-fast bacillus; that is, if stained with an anilin color, mineral acids will not wash out the stain. All acid-fast bacilli are capable of producing lesions that, to some extent at least, resemble tuberculous lesions; but the lesions produced by all except the tubercle bacillus and the leprosy bacillus tend to cure. It is possible that all acid-fast bacilli are branches from a common stem.

The tubercle bacilli obtained from different animals differ considerably, both in morphology and in virulence. Koch has maintained that the bacilli of human tuberculosis differ radically from those of bovine tuberculosis, that human tuberculosis cannot be given to cattle at all, and that it is so difficult to transfer bovine tuberculosis to the human being that the danger from infected cattle is utterly trivial and may be disregarded. Ravenel and others have positively opposed this view of Koch's and there have been reported what appear to be undoubted cases of the transference of tuberculosis from animals to man. There is still dispute upon this point;

but most writers believe that bovine tuberculosis and human tuberculosis are essentially the same, although the bacilli present temporary differences due to altered environment. The bacilli of bovine tuberculosis are certainly less dangerous to man than are the bacilli of human tuberculosis, and the bacilli of human tuberculosis are less dangerous to cattle than are the bacilli of bovine tuberculosis.

Nocard reports 2 cases of individuals who wounded themselves while cutting the meat of tuberculous cattle. Both developed generalized lesions and died. Ravenel strongly opposes the view of Koch and maintains that the bacillus of bovine tuberculosis is highly pathogenic for man ("University of Penn. Med. Bull.," xiv, 238, 1901). The same author reports 2 cases of tuberculosis of the human skin due to inoculation with bovine bacilli ("Phila. Med. Jour.," July 21, 1900).

Distribution of the Bacilli.—These bacilli are parasites, and not saprophytes; and the real, and only, source of infection is a tuberculous person or animal. Wherever there are tuberculous men or animals, the bacilli get into the air. The number that get into the air depends upon the number of animals affected, the seat of the tuberculous lesion in each, the care taken by the victims, and the control exercised by the community.

The tubercle bacilli from an infected individual may get into the atmosphere from the urine, the sputum, the feces, the sweat, the milk, or caseous or purulent material. The bacilli from dried sputum enter the dust, in which, fortunately, they are usually destroyed quickly by the complete dryness, the oxygen of the air, and the sunlight; but under some circumstances they may retain their virulence for weeks or even for months. The infected area itself is usually the direct source of the bacteria from a given case of tuberculosis, but this is not invariably so; for a tuberculous woman with a healthy mammary gland may secrete milk containing tubercle bacilli, a consumptive free from genito-urinary tuberculosis may occasionally pass urine containing bacteria, a cow may give tuberculous milk when the udder is not diseased, and tubercle bacilli may enter the bile of a tuberculous patient. It is probable that flies and insects may transmit infection (Lord, in "Boston Med. and Surg. Jour.," 1904, cli); and it is sure that putrefaction does not certainly destroy the tubercle bacilli. This is proved by the fact that living bacilli may be passed in the feces of an animal that has been fed on tuberculous meat, and that they may be found in the feces of an individual suffering with intestinal tuberculosis. We are thus justified in concluding that slaughter-house waste, if improperly disposed of, is a danger to the community.

Routes of Infection.—An individual may acquire tuberculosis by inhaling tuberculous material (*inhalation tuberculosis*), by swallowing tuberculous material (*ingestion tuberculosis*), and by inoculation with tuberculous material (*inoculation tuberculosis*). Infection of the lungs is commonly brought about by the inhalation of dried tuberculous sputum, or dust carrying tubercle bacilli. Ingestion tuberculosis may follow the eating of tuberculous meat, the drinking of tuberculous milk, or the consumption of uncooked articles on which tubercle bacilli have gathered. It has been shown that the lacteals may take up tubercle bacilli from the intestine, even if there is no intestinal lesion; and that bacilli can pass through the thoracic duct and into the blood, and lodge in some tissue, particularly the pulmonary tissue, so inducing tuberculosis. They tend to

lodge at any point of least resistance; and if not caught up in the lungs, will tend to be arrested in some other region that has been the seat of a trifling injury,—for instance, in an epiphysis that has been strained. It is a peculiar fact that a trivial injury constitutes a point of least resistance; but a severe injury, such as a fracture of a bone, does not do so. Baumgarten was a strong believer in the idea that bacilli enter the organism with the food and von Behring now warmly advocates the same view, teaching that bacilli enter the organism of every person in early life. They may be destroyed by tissue resistance, but if not destroyed have a period of latency and finally, perhaps after years, become active and cause the disease ("Deutsche Med. Woch.," Sept. 24, 1903).

It is certain that inoculation may be followed by tuberculosis. The inoculation of tubercle bacilli in the intestine produces intestinal ulceration. It has been shown experimentally that rubbing the bacilli into the nasal mucous membrane may produce a local area of disease. Inoculation of the skin may result from a wound, the bacilli being carried into the wound itself. The usual victims of cutaneous inoculation are butchers, physicians making post-mortem examinations, and workmen that handle hides. In these cases, as a rule, an ulcer promptly forms at the point of inoculation; but in some few cases, the wound heals soundly, and tuberculous lesions develop in its neighborhood. In still rarer instances, no apparent inflammation or ulceration occurs in or around the seat of inoculation; but the anatomically related lymph-glands become tuberculous.

A number of cases of inoculation tuberculosis have been reported. I myself have had one, in a physician, who inoculated his finger while making culture studies with tuberculous material. In this case, the axillary glands became tuberculous. I have also seen a tuberculous ulcer of the forearm in an attendant of a lunatic asylum, who had been bitten by a tuberculous patient. Inoculation tuberculosis occasionally follows circumcision, as practiced by an orthodox rabbi, the operator having been tuberculous. There have been reported apparent cases of direct inoculation of the genito-urinary tract during sexual intercourse. If there has been some definite injury of the tissues, inoculation may follow a simple rubbing of tubercle bacilli into a part.

When the mother's ovum is tuberculous, the disease may be directly transmitted to the fetus, producing the condition known as congenital tuberculosis; and it seems possible that tuberculous sperm-cells may be responsible for the same condition. Baumgarten believes that bacilli may pass the placenta, enter the fetus, and remain lateral for years. Latent bacilli have been found in normal lymph-nodes (Harbitz, in "Jour. Infect. Diseases," vol. ii, 1904); this proves that latency is possible. The direct transmission of the disease, however, is unusual, but the transmission of a hereditary predisposition to infection is not unusual. In some cases of tuberculosis we can satisfy ourselves clinically as to the cause of the infection. For instance, when an individual is injured with an object known to carry tubercle bacilli, if an ulcer of the skin forms, and the adjacent lymphatic glands enlarge, the deduction is obvious. In other cases, it is impossible to make up our minds as to the cause of a tuberculous lesion. For instance, we can only guess that a person has inhaled tuberculous material or has eaten tuberculous food. If in inoculation tuberculosis no lesion arises at the point of entry, the opinion as to the causation will be founded merely upon guess-work.

It seems sure that when the bacilli of tuberculosis enter into the body, if they are not destroyed by the body-resistance, they either produce a local lesion at the site of inoculation, or pass to the nearest lymphatic glands, and there establish disease. The first lesion is known as the primary focus, and from this focus the disease may be disseminated to the most distant parts. The bacilli enter readily, if there is a wound or an abrasion; but in exceptional circumstances, they may enter through unbroken skin and undamaged mucous membrane. Any structure may become tuberculous, but some structures are much more liable to do so than are others. The lungs are very liable; the conjunctiva is very resistant.

It is seldom that infection is disseminated by the blood-stream; as a rule, it is effected by the lymph. Dissemination by the blood-stream means rapidly advancing and widespread tuberculosis; dissemination by the lymph-stream means slowly advancing tuberculosis, with localization of lesions. In dissemination by the lymph-stream, the dissemination is usually in the normal direction of the lymph-current; but if the lymph-vessels become blocked, lymph-regurgitation may occur, and then the dissemination is in a direction opposite to the normal flow of the lymph-current.

Products of the Tubercle Bacilli.—A great variety of products are formed by the tubercle bacillus, and among them we may mention alkaloids, toxalbumins, fatty acids, and ferments. Experimental injection of the toxalbumins produces inflammation; and of the alkaloids, fever. It has been shown by Maragliano that injection of the toxalbumins actually lowers the temperature. Beyond any doubt, the culture-material in which tubercle bacilli grow contains poison; and the bodies of the bacilli themselves contain poison. The poisons in the culture-medium are called *extracellular poisons*, and those within the bacilli are called *intracellular poisons*. It is quite probable that the former poisons are the same as the latter, and have merely passed from the bacilli into the culture-medium.

Tuberculin.—It was proved some time ago that dead bacilli are toxic and, if experimentally injected, induce a toxic condition in the animal, cause inflammation of the kidneys, and sometimes produce cold abscess subsequently at the seat of injection. Koch collected the poison from dead bacteria in the form of a liquid, which he called tuberculin. A number of different methods of extracting such poison have been suggested; hence, there are a number of different tuberculins. Koch has made several himself. His early tuberculin was a glycerin extract of a culture of tubercle bacilli; his later tuberculin is made from the dried bacilli, ground up, and mixed with water, the fluid being centrifuged. When centrifuged, two layers separate. The upper layer is the old tuberculin, and the lower layer is the new tuberculin. Koch calls this new tuberculin tuberculin oberst (Tuberculin O.).

It was discovered by Koch that tuberculous animals are much more strongly affected by an injection of tuberculin than are healthy animals. The most positive reaction is noted in the tuberculous area; but, as a rule, there is also a reaction in the area where the injection is made. We get no reaction from the administration of tuberculin by the stomach, but occasionally can obtain it by the inhalation of the dried material. If a moderate dose of tuberculin is injected into a non-tuberculous animal, there may be a trivial redness at the point of injection and a slight and temporary rise of temperature; or there

may be no evidence of reaction whatever. An injection in a tuberculous animal, however, is followed by distinct inflammation at the seat of injection, and a positive reaction in the tuberculous area. This area undergoes congestion or inflammation, leukocytes collect around it, and the part tends to necrosis, and is liable to break down.

In addition to the changes already mentioned, there is elevation of temperature. If the dose has been small, there may be only a slight feeling of coldness to usher it in; but if the dose has been large, there is usually a distinct chill. This chill comes on eight to twelve hours after the injection and is accompanied and followed by elevated temperature. The fever lasts from four to twenty-fours hours, and the temperature is elevated to from two to five degrees Fahrenheit. The febrile condition is accompanied with pain in the head, limbs, and back, and with increased rapidity of the circulation, restlessness, weakness, and usually nausea. As the temperature passes to normal all the symptoms disappear. The slight elevation of temperature when tuberculin is injected into a non-tuberculous animal is not ushered in by a chill, and does not exceed one degree Fahrenheit, unless a very large dose is given. We thus note that the injection of tuberculin may be of the greatest possible value in diagnosis.

A good many observers have grown fearful of injecting tuberculin, believing that it is liable to cause the tuberculous focus to spread, or actually to lead to the development of disseminated tuberculosis. Virchow was of this opinion. That such a condition may follow the use of large doses seems certain, but moderate or small doses appear to be entirely safe. Flick has pointed out that if a blister is applied to a tuberculous person a distinct febrile reaction appears a number of hours after the application. This is due to the absorption of toxic material, probably tuberculin, from the blister. It is known that in a tuberculous animal certain excretions (urine) and serous exudates contain tuberculin. Mérieux and Baillon show that if a tuberculous person is blistered the fluid of the blister, injected into a tuberculous animal, produces a definite reaction. This proceeding is of diagnostic value. The tuberculin comes from the tuberculous person and he is proved to be tuberculous by injecting the tuberculin into another tuberculous animal.

Professor Behring (Paris Congress of Tuberculosis, Oct., 1905) maintains that there is a curative principle not identical with antitoxin. He obtains a substance from tuberculous material, which he calls T. C. and he introduces this substance into the living body. When T. C. is acted on by the cells of the living body, it is altered; and the hypothetical material, T. X., is formed. This distinguished laboratory worker says that the T. C. is the vital principle; and that when cattle are immunized by inoculating attenuated bacilli, the T. C., by acting on the body-cells, is responsible for the diagnostic reaction to tuberculin and for the protective action towards tuberculosis. Some try by means of supposed antitoxins to immunize the body-fluids, but he tries instead to immunize the body-cells. He is unwilling to inject living tubercle bacilli into human beings; so he frees the tubercle bacilli of certain substances, leaving an organism that resembles the tubercle bacillus, which he calls the rest bacillus. This rest bacillus is, by certain methods, converted into an amorphous material identical with the T. C. formed by the action of

the body-cells upon the virus. This T. C. is taken up by lymph-cells; and it so changes these cells that they are converted into eosinophiles or oxyphiles, and the change in these cells makes the body immune. T. C. may safely be injected, as it is not a living material; and, whereas it may produce tubercles, they do not tend to caseate. Professor Behring believes that this material may be used in the treatment of human tuberculosis.

Resistance of Bacilli.—Among the antagonistic elements, we have mentioned oxygen, dryness, and sunlight. Moist heat, at the temperature of boiling water, is rapidly fatal. A 5 per cent. solution of carbolic acid is one of the most powerful of germicides. Full-strength alcohol is next in point of power. Corrosive sublimate is not a satisfactory germicide. Formaldehyde is fatal only after long exposure. Iodoform and ether is a reasonably powerful mixture.

That the virulence of tubercle bacilli varies under different circumstances is sure. Under some circumstances they may be extremely powerful; under others nearly innocuous. The liability to infection depends, perhaps, in part, on individual predisposition, and certainly, to a great extent, on the number and the virulence of the bacteria.

Immunity.—It seems likely that some persons are immune to tuberculosis—persons coming from an ancestral line in which all the predisposed have died off, so that the immediate ancestors of the line were non-susceptible. The tendency to immunity may be strengthened by proper marriages, and may be weakened by improper marriages; or immunity in a line may be destroyed by the continuance of unfavorable conditions. Of course, the term immunity is only relative. No one can be absolutely immune; for when subjected to extremely unfavorable circumstances, or when a number of virulent bacilli are introduced, anyone may become tuberculous.

Predisposition.—Personally, I believe that there is such a thing as a predisposition towards tuberculosis; just as there is towards many other diseases. Such a predisposed individual has temporarily or permanently acquired a condition of the body-cells, body-fluids, or both, that either makes easy the entrance of the bacilli, or prevents strong opposition to their multiplication when they have entered. A person is predisposed when the opsonic index is low, for this indicates lack of phagocytic power in the leukocytes. Predisposition may be increased by some extraneous circumstance, such as occupation, residence, etc., that brings the individual into frequent or prolonged contact with virulent bacteria.

There is certainly such a thing as congenital tuberculosis, although it is unusual; and any tissue may be involved in the congenital trouble. Young children are very liable to tuberculosis of the acquired form. According to Professor Behring, many children become infected with tuberculosis in their early years by eating tuberculous food; but such a tuberculosis often remains latent for a considerable length of time, and then develops. This theory obtains probability from the fact that the digestive organs of the child are not strongly protective against bacteria as are those of the adult.

A question is, Do certain individuals possess a special predisposition to develop tuberculosis, and is this hereditary? Hereditary predisposition was once regarded as practically the only cause of the disease, but many thinkers now regard it as of slight importance; although I do not see how we can deny

its existence. We all see how common is tuberculosis in the descendants of tuberculous persons. Hutley studied 432 cases of tuberculosis. In 23.8 per cent. one or both parents had the disease (the father alone in 11.5 per cent., the mother alone in 9.9 per cent., and both in 2.4 per cent.). Some maintain that in 30 per cent. of consumptives, one parent or both parents have been consumptives; and in 60 per cent. a parent or a grandparent has suffered with tuberculosis. Because of the extreme frequency of the disease, however, this statement does not prove that the cases in the family are due to heredity; but that there must be such a thing as hereditary predisposition is indicated by the fact that there are many families living under similar conditions to the tuberculous families, without there having occurred, through several generations, a single case of tuberculosis among their members. A feature that makes us unable to reach a certain conclusion is that tuberculosis is contagious; and several members of a family may be infected from one member, even when there is no predisposition to the trouble by heredity. The mere living in one house may account for the infection. A fact strongly in favor of the hereditary influence is that in a family whose ancestors have been tuberculous and whose members have not lived together, but have been scattered widely over the earth, member after member may die of the disease.

Unhealthy environment particularly predisposes to tuberculosis; and the element of poverty—leading, as it does, to taking improper or insufficient food, dwelling in an unhygienic room or in an overcrowded building, pursuing an exhausting occupation, working for long hours, and obtaining insufficient amusement and outdoor exercise—also has a most powerful unfavorable effect. As a class, the poor dislike ventilation, take insufficient exercise in the open air, do not get enough sunlight, work in a dusty atmosphere, eat improper food, and not enough of it, live in damp and dirty rooms, and many of them drink quantities of whiskey. City life is a predisposing cause of tuberculosis, for many of the foregoing reasons, and particularly because many city workers follow an indoor occupation. The enemies of tuberculosis are sunlight, fresh air, nourishing food, and outdoor exercise; and the limiting of any of these factors favors the development of the disease.

Tuberculosis may occur in any region that man inhabits; although in some regions it is rare, and in others it is excessively common. Its great frequency in some regions is probably due less to climate than to environment, occupation, and heredity; and the greatest predisposition is found in the town dweller. There is much more tuberculosis among males than among females.

An injury may be followed by the development of tuberculosis at the seat of injury, the injury creating a point of least resistance in which bacilli may lodge. A slight injury of a joint or a bone is the most common traumatic predisposition; although a chest injury may be followed by tuberculous pleuritis, and a head injury by tuberculous meningitis. The injury that predisposes, as previously stated, is a trivial, and not a severe one. In some cases in which tuberculosis develops after injury, the injury has been a mere coincidence; in others, a region the seat of an undeveloped tuberculosis has been affected by the injury, and the tuberculous process has thus been awakened into activity. If there is no tuberculous focus at the seat of injury, we are justified in concluding, when tuberculosis develops, that a point of least resistance has been created. Such points are more common in those that have a focus of

tuberculosis somewhere about the body, but may apparently occur in those that have no such focus. Many diseases and conditions predispose to tuberculosis. Tuberculosis is very common in chronic drunkards, in the insane, and in the sufferers from tertiary syphilis, diabetes, and Bright's disease. Any exhausting malady may be followed by tuberculosis.

The Term Scrofula.—Many surgeons positively oppose the use of the term scrofula, but I believe that there is clinical value in retaining it. The surgeons that have entirely abandoned it think that, after all, it is exactly synonymous with tuberculosis. I use it to designate the persons that are predisposed to tuberculosis through possessing a type of tissue of low resisting power. These tissues fall a ready prey to the bacteria of tuberculosis. Such tissue-vulnerability is usually hereditary; and, as a rule, one, or even both parents are tuberculous, are in ill health, or are themselves predisposed. Occasionally this type of tissue is acquired, a child having at first been apparently entirely healthy; and later, owing to poor food, insufficient air, and bad hygienic surroundings, developing scrofula.

That scrofula is not simply osseous, articular, or glandular tuberculosis is proved by the fact that a person that we recognize as scrofulous may never throughout his life develop a tuberculous lesion. Some surgeons think that scrofula is latent tuberculosis, and will, under the influence of some exciting cause, burst into activity. This is possible, but unproved. We do know that some so-called scrofulous lesions are not tuberculous; for instance, facial eczema, corneal ulceration, granular lids, and mucous catarrh. These lesions are rather expressive of poor health, improper food, and deprivation of fresh air.

The subjects of scrofula, besides being prone to the non-tuberculous lesions above mentioned, are particularly prone to develop tuberculous lesions; and such a lesion may arise in any part that has been the seat of a slight injury or of a non-tuberculous inflammation. The parts most apt to become tuberculous are the bones, the joints, and the glands.

There are two types of the so-called scrofulous, that is, two types of those that are predisposed. The common type is known as the *phlegmatic*, or *lymphatic;* and it is this type that is particularly described by our surgical forefathers. In the phlegmatic type, the individual is stolid of expression; and has thick, coarse skin, a muddy complexion, dark, coarse hair, a thick neck, thick lips, a thick nose, and a heavy lumbering gait. He is dull of apprehension, with feeble emotional reaction, and but little capacity for concentration or interest. The other type is much more seldom met with. It is what is called the *sanguine type*, or what the elder Gross spoke of as the *angelic type*. Such a child is frequently beautiful, and graceful in its movements. Its skin is transparent and clear, and the color comes and goes. The eyes are blue, the lashes long, and the hair silky. The tendency is to thinness, rather than fat; and the mind is not dull, but precocious and the temperament is nervous. In both these types of scrofula, the condition of lymphatism exists.

Lymphatism, or the Lymphatic Constitution (Status Lymphaticus).—This term was introduced by Potain to designate a condition in childhood in which there is a very strong disposition to the development of disease of the lymphatic structures, or in which at birth there was excessive development of these structures. The enlarged glands may be tuberculous from

the beginning; but, as a rule, they are not so in the beginning, but tend to become so. Inflammation of a mucous membrane is followed by enlargement of the anatomically related lymphatic glands. These enlarged glands are frequently met with in the neck. We find them associated with enlarged tonsils and pharyngeal adenoids.

Usually lymphatism is congenital, but it may be acquired when children are placed under unfavorable conditions. Lymphatic children frequently have rickets and are invariably anemic. In infancy, it is the bronchial and mesenteric glands that are particularly apt to enlarge; in childhood, it is the glands of the neck. In lymphatic children, it is not uncommon to have a persistent thymus gland. In some cases a goitre appears. As the child increases in age, the lymphatic enlargements are likely to disappear, unless tuberculous infection has occurred. After a child has reached the age of seven or eight years, non-tuberculous glands of the neck cease to enlarge; and by the time of puberty, they have usually disappeared.

If an operation is performed on the victim of lymphatism the wound is very liable to become infected; and the bleeding from the wound is very trivial. The victims of lymphatism are more apt than other persons to die under a general anesthetic, and occasionally one of them dies during natural sleep. (See Dr. Geo. Blumer, in the "Bulletin of the Johns Hopkins Hospital," Oct., 1903.)

The Diagnosis of Tuberculosis.—Whenever he sees a persistent area of chronic inflammation in any structure of the body the surgeon must think of the possibility of its being tuberculous. A thorough investigation must be made into the local disease and the body generally; and of particular importance is it to determine whether there is any other diseased locality, and whether there is any evidence of tuberculous disease anywhere in the body. The patient's history must be investigated, and any possible tendencies or predispositions inquired into.

In many cases of tuberculosis, the diagnosis can be made from purely clinical investigation. This is the case, for instance, in many tuberculous ulcers, abscesses, and glands. In some cases the diagnosis can be made only by making differential stains of material obtained from the suspected focus, or by removing a section of the inflammatory area with a Mixter's cannula, and studying it carefully under the microscope. Cultures may be taken from any material obtained from the suspected focus.

In doubtful cases, animal inoculation is necessary to make a diagnosis. The material is injected into a guinea-pig; and if it be tuberculous, the animal will develop miliary tuberculosis within a few weeks. With apparently sterile fluid obtained from a tuberculous focus, the disease can be induced in guinea-pigs by inoculation. Blistering a tuberculous person causes elevated temperature (page 219). If the fluid of the blister be injected into a tuberculous animal a distinct reaction occurs (page 219).

In a suspected case of tuberculous meningitis of the brain or of tuberculous disease of the membranes of the cord, the theca of the cord should be tapped (lumbar puncture), and the fluid obtained should be carefully examined. Of course, if, in a case of tuberculous cerebral meningitis, the foramina in the floor of the fourth ventricle have been blocked by exudate, no characteristic fluid will be obtained by tapping. It is usually found, however, that even in tuber-

culous cerebral meningitis, there is increased tension of the fluid in the subarachnoid space of the cord, that this fluid is present in unnaturally large quantity, and that it is turbid through the presence of pus and white blood-cells. Sometimes it contains bits of fibrin, and sometimes blood; and in many cases, the bacilli of tuberculosis. Exploratory abdominal incision is sometimes necessary to determine the existence of tuberculous peritonitis.

The *x*-rays are of great aid in making a diagnosis of osseous, articular, and perhaps certain forms of pulmonary tuberculosis. The area of tuberculosis is lighter than the surrounding healthy structures when seen by the *x*-rays.

The tuberculin test may sometimes be used to very great advantage. We have already said that if given in moderate doses, it is safe; that is, it is safe if the disease is not too far advanced. Very large doses, or the giving of the remedy at all in greatly advanced tuberculosis, would not be safe. When we wish to make a diagnosis by means of tuberculin, we give a dose of 1 mg. of the fluid hypodermatically. If no reaction occurs within twenty-four hours, a dose of 2 mg. is given. If there is no reaction from this dose, the surgeon waits another twenty-four hours, and gives a dose of 3 mg., and he so keeps on, advancing the dose until he reaches the amount of 8 or 10 mg. Ten mg., however, is the maximum dose for diagnostic purposes. If after the administration of one of these doses a reaction is obtained, no further administration of the drug is, of course, desirable.

It is the advice of Dr. Norman Bridge that distilled water be added to the tuberculin until the tuberculin-strength is 10 per cent. This water should contain 2 per cent. of carbolic acid. When ready to administer the material the fluid is made into a 1 per cent. solution by diluting with distilled water. The 1 per cent. solution, as Dr. Bridge says, represents a milligram of tuberculin to a minim and a half of fluid.

Tuberculin is not to be given for diagnostic purposes unless the temperature of the patient is normal or very nearly normal; and, as Dr. Bridge points out, when we make the tuberculin test, the temperature should be taken every two hours for twenty-four hours before the test and at like intervals for a like length of time after, in order to know thoroughly the effect that has been produced.

We have previously described the tuberculin reaction; that is, the local congestion or inflammation in the tuberculous area, and the chilly sensation or chill, followed by marked elevation of temperature. In certain tuberculous lesions we can see the local reaction; for instance, in lupus. In joint tuberculosis the skin over the joint becomes red. In a tuberculous ulcer of the mouth we can see the changes; and in a lesion of the larynx the laryngologist can observe them with the laryngoscope. By means of a cystoscope the local reaction can be seen in a tuberculous ulcer of the bladder.

Not only should this test not be used in advanced pulmonary tuberculosis because it is unsafe but it is also needless in any advanced case because the diagnosis is perfectly clear without it. We never should give extremely large doses in making the tuberculin test, because an extremely large dose may obtain a positive reaction even in a healthy man. A person with actinomycosis or secondary syphilis may show a reaction to tuberculin which confuses our results. If, after the careful use of tuberculin, there is no reaction, it is usually a safe conclusion that there is no tuberculosis.

The agglutination test, as applied to the blood-serum of a tuberculous individual, is decidedly uncertain. It is very unusual to be able to find bacilli in the blood, though they may occasionally be found there in miliary tuberculosis.

Prognosis.—Many cases of tuberculosis are cured. This is indicated by the frequency with which we find healed tuberculous lesions in necropsies on individuals dead of other diseases. We reach the same conclusion from the clinical study of many cases. The prognosis of a single tuberculous focus, especially if it can be extirpated or sterilized, is very good; provided that the general health is good, that there is not much anemia, that the digestive processes are well performed, that mixed infection is absent, that there are no albuminoid changes in the viscera, and that the patient is able and willing to live the life that is necessary for his welfare. Of course, the prognosis is influenced by the patient's temperament, his willingness to brook control, his monetary status, and his habits. The danger is greatly increased by multiple lesions. The dangers of mixed infection and of albuminoid disease have been previously discussed.

In very young children the prognosis is most unfavorable; but in older children it is very much better; in fact, it is better in them than in adults.

Tuberculosis of the skin gives a very fair prognosis; and glandular, bony, and articular tuberculosis are frequently recovered from: but, of course, any tuberculous lesion, however limited in area, is a profound menace.

Another fact to be borne in mind is that many cases apparently cured are not really cured; and that the disease strongly tends to reappear in the same region or in a nearby region, or to reappear later in another part of the body. We should, further, remember that in many cases in which there is apparently one lesion only, there are, in reality, distant lesions undiscoverable by clinical methods. In any case of tuberculosis the higher the opsonic index the better the prognosis, the lower the opsonic index the worse the prognosis (page 38).

Another important fact is that when an individual has a latent focus of tuberculosis, especialy if this latent focus is in the lungs, should a surgical operation be performed for some other purpose, and the patient be kept in bed for a considerable length of time, the latent focus may become active. I have always believed that in latent pulmonary tuberculosis the administration of ether or chloroform might waken the disease into activity. It therefore becomes evident that in such persons operations of necessity are the only ones that should be undertaken. Such an operation, if possible, should be done under a local anesthetic; and the patient should be got about again at the earliest possible moment.

Treatment.—One of the first thoughts of the surgeon is to provide against the contamination of healthy individuals by the infected. Any infected excretion or suspicious discharge from the patient must be disinfected at once and dressings that are removed from the patient should be burned.

We are not in this section discussing the treatment of tuberculosis of the lungs, which belongs to the medical man, and in which climate is of the first importance. In cases of surgical tuberculosis, however, the patient may do better in some climates than in others; and the change, by stimulating the appetite and causing him to sleep and giving him renewed hope, will be bene-

ficial. In surgical tuberculosis, climate is not the factor that it is in tuberculosis of the lungs; but if there is pure atmosphere, an equable temperature, and plenty of sunlight, the climate will lure the patient out-of-doors, and will thus be greatly to his advantage.

A life in the open air is the most essential thing in the treatment of surgical tuberculosis; but, as Professor Halsted points out, it is not of much use to tell a great many persons to live in the fresh air. They will not do it, unless they are made to; and it is hard to make them unless they live in quarters especially built with this object in view. Therefore, other things being equal, if the patients with surgical tuberculosis have the means, it is a good plan to send them to a sanitarium in the mountains or at the seashore, where they can obtain the persistent, unbroken life in the open air that is the cure of the disease. The patient should spend his days in the fresh air, and he should sleep at night directly exposed to the air; and if the atmosphere is free from dust and foul odors, so much the better. The poorer patients must get the fresh air at home, if they cannot be sent to some camp or colony. In large cities adjacent to the seaside resorts, poor people can usually be sent for a short time, at least, to the seaside; and I am a very great believer in the beneficial effects of Atlantic City and other seashore resorts.

It is frequently necessary to do an operation in a great city, although we operate much less than formerly for these conditions. If an operation is done in a great city, the patient is kept in the fresh air as much as possible during his convalescence. If it is feasible, he is sent away to a colony or sanitarium to recuperate. It would be an excellent thing if, in many of those cases in which operation is necessary, the operation could be performed at the camp or the sanitarium. One advantage of the camp or sanitarium is that the patient is watched and regulated daily, and is led to do things that otherwise he would neglect. Many patients endeavor to evade going out when they should, because they are afraid of taking cold; and many of them are just neglectful and do not want to take the trouble to do it.

It cannot be too strongly insisted on that in surgical tuberculosis fresh air is of as much importance as in tuberculosis of the lungs. It increases the vital resistance, it stimulates opsonic power; and it causes the patient to eat more nourishing food and to sleep better at night. Frequently we see children that have had sinuses for months get rapidly well when they adopt an open-air life; and, although albuminoid changes, when they once exist, will never pass away, further albuminoid changes may not take place if the patient lives properly.

A patient with surgical tuberculosis can have no more injurious environment than a dark, damp room, especially if it is in a crowded tenement and up a narrow court. The value of sunshine is also beginning to be appreciated. We know that it limits the growth of tubercle bacilli. It is not the heat that benefits the person, but the chemical rays of sunlight. These rays have some germicidal influence, have considerable penetrating power, and seem to influence decidedly the nutritive processes.

The area of tuberculosis requires rest. We have long known how disastrous it is to confine a person to bed in a dark, ill-lighted, and improperly ventilated room. We can, however, confine a person to bed with perfect safety if there is a free flow of fresh air. We must confine certain cases to bed; for

instance, cases of tuberculous peritonitis, and some cases of bone tuberculosis, and of joint tuberculosis. A patient with tuberculosis who has fever ought to be in bed. We can put such patients to bed without any fear of the disease becoming worse or spreading if the supply of fresh air is plentiful and if the patient is kept warmly covered and wears a skull-cap. Of course, a draft is to be avoided. Patients that are confined to bed do excellently in a tent, in a cottage sanitarium, or on a porch that has been altered for the purpose.

At the very first possible moment the patient should be got out-of-doors; and in many cases of tuberculous disease (for instance, vertebral disease), the tuberculous part is supported by means of a brace or a splint.

We thus see the two-fold nature of the modern treatment of surgical tuberculosis: rest for the tuberculous part and a life in the open air. Exercise is of importance also, although it should never be taken in excess. If the patient is confined to bed, he should be massaged and rubbed with alcohol, the tuberculous part being avoided. Manipulation must never be applied to a focus of tuberculosis because it may lead to dissemination. If a person has fever he must not attempt active exercise, but must be confined to bed.

One should overfeed tuberculous patients, if the stomach tolerates it; but not on any single article, or even on any particular one. The diet should contain a sufficiency of fats, proteids, and carbohydrates; and the food should be agreeable to the taste and readily assimilable. Otherwise, disgust will be engendered; and with disgust comes indigestion and loss of appetite. The very life of the patient may depend on his remaining able to take a sufficiency of nourishing food.

There is no specific diet for tuberculosis, although many have been suggested. One of the most valuable foods is milk, taken raw or mixed with other articles, such as lime water or sodium carbonate, and frequently with brandy. The use of an exclusive diet of boiled milk is to be deprecated, and in children it sometimes leads to the development of scurvy. Practically anyone can take milk, if proper efforts are made.

Soft boiled eggs are useful; and bread or toast should be eaten with plenty of butter, which is an agreeable form of fat. Vegetables and fruits are desirable.

If the patient can take cod-liver oil without impairing his appetite or digestion, it should be given; provided the weather is not too hot. Cod-liver oil produces diarrhea in very hot weather. Children learn to take it very well. To many adults, however, it is, and remains, absolutely abhorrent. The chief value of cod-liver oil is that it is a fat, and it seems improbable that it contains any elements specifically antagonistic to tubercle. If used, large doses should not be given; as they will not be digested. The common dose for an adult is a teaspoonful two or three hours after meals. Thirty drops three times a day is usually given a child, and an infant should receive 15 drops three times a day.

There is no satisfactory specific treatment for tuberculosis, every suggested one having failed on a careful test. We do know that we can induce immunity in animals by the injection of attenuated living bacilli (Trudeau), but we cannot venture to endanger a man's life by making such attempts. As previously pointed out, von Behring believes that he is able to produce immunity in man; but in any case, producing immunity is a different thing from curing an existing disease. We no longer have high expectations of

tuberculin. It is never given in advanced cases or if there is secondary pyogenic infection. Its use is limited by most practitioners to the treatment of lupus in which disease it is sometimes of value. When used it is given in small doses, far smaller than those given for diagnosis (page 224). Antitoxin obtained from a horse supposed to have been rendered immune is of doubtful value. We know of no drug or medicine that can with safety be used at the present time with any real hope that it will specifically destroy tubercle. Drugs are, of course, given; but they are of secondary importance.

Tonics are used, and in children, the syrup of the iodid of iron has considerable reputation. Remedies may be needed to improve digestion, to control night-sweats, etc. I do not believe that beechwood creasote or carbonate of guaiacol internally, or iodoform inunctions, or painting the surface with guaiacol confer any real benefit in tuberculosis.

Alcohol is often required. It is not needed in all cases, but is in many. We should avoid it in children, however, unless there is a particular indication for its use. When a tuberculous patient is weak, milk-punch or egg-nog is of service; and in any case of mixed infection, alcohol is required in full doses. If fever exists, and the administration of alcohol makes the pulse more rapid and the delirium worse, and causes flushing of the face, the dose is too large and should be diminished. Any patient that smells strongly of alcohol is getting an overdose.

The Local Treatment of Tuberculosis.—When certain drugs are directly inserted into a tuberculous focus, they do possess an antagonistic influence. Iodoform is the most powerful of these drugs; guaiacol, balsam of Peru (Landerer), and chlorid of zinc (Lannelongue) have a similar action. Iodoform has little or no influence when placed on a free surface exposed to the air; but when in the form of an emulsion it is injected into a tuberculous area, the air being excluded (page 29), this drug is powerfully antituberculous. Chlorid of zinc seems to act by causing the development of quantities of fibrous tissue, which encapsulates, or perhaps replaces, the tuberculous focus. Some surgeons inject tuberculous nodules with camphorated naphthol. Every region of tuberculosis requires local rest, perhaps by the use of a splint or a brace.

Special Methods of Surgical Treatment.—The surgeon may endeavor to extirpate a tuberculous focus, or to drain it thoroughly and to sterilize the area. Extirpation is sometimes, although not very frequently, possible. Complete extirpation is a valuable method, but partial extirpation is dangerous. If a part only of a tuberculous focus is extirpated, many lymph-tracts and blood-vessels are opened; and the incomplete operation may lead to the dissemination of the disease. The methods of surgical treatment suited to different forms of tuberculous disease will be discussed in different sections of this book.

Bier's Method by Congestive Hyperemia.—Bier believes that passive hyperemia is of the greatest possible benefit. Active hyperemia is obtained by heat, and is especially valuable to induce the absorption of the products of a non-tuberculous chronic inflammation. Passive hyperemia is particularly useful in tuberculosis and, if a limb is affected, is obtained by placing a rubber band around the limb above the part, the band being applied with sufficient firmness to interfere with venous return, but not so tightly as to block arterial entry. This band should be applied daily, and should be kept in place for

an hour or so or several hours at a time. When the band is put on, for instance, above the knee, an ordinary bandage is applied from the toes up to just below the knee; and thus the blood is imprisoned in the desired region. In the intervals between the treatments the limb should be at rest. Bier uses special apparatuses for obtaining congestive hyperemia in various parts of the body.

I have seen cure or very great improvement follow this treatment in a number of cases. It is founded on the old idea of Laennec that cyanosis and tubercle are antagonistic. Why this method is beneficial is much debated. Some think that the imprisoned blood takes on increased bactericidal power; some, that the number of leukocytes is greatly increased; some, that quantities of leukocytes migrate; and some, that the amount of bactericidal blood-serum is increased. Bier believes that it depends upon phagocytosis. It would seem possible that the cells in this locality, under the influence of the congestive hyperemia, may form powerful antitoxins.

The Finsen Light.—Finsen pointed out that the chemical rays in sunlight are powerfully germicidal, and that this germicidal power can be notably increased if the rays are concentrated on a part by the use of particular apparatus. He also showed that enormous numbers of chemical rays can be obtained from electric light. The Finsen treatment to-day consists in applying the actinic rays obtained from electric light. They act most powerfully on lupus, but require a very long time to effect a cure.

The X-Rays.—The *x*-rays are of value in treating certain tuberculous conditions. They are of most use in lupus, their effects in this disease being nearly as powerfully curative as those of the Finsen light, and much more rapid.

Tuberculous Abscess.—For description of this see page 145.

Tuberculosis of the Skin.—Tuberculosis of the skin may arise from inoculation with material derived from a bovine or human source. It is frequently found that some other member of the family labors under tuberculous disease or that some family predecessor, direct or collateral, suffered from it. Stelwagon ("Diseases of the Skin") includes all cases under five heads: (1) tuberculosis ulcerosa; (2) tuberculosis disseminata; (3) tuberculosis verrucosa; (4) scrofuloderma; (5) lupus vulgaris.

Tuberculosis Ulcerosa.—The disease arises by a mucous outlet and is usually secondary to internal tuberculous disease. Small miliary tubercles form which caseate and are converted into ulcers. The ulcers are shallow, round or oval in outline, with soft edges, the floor being composed of sluggish or edematous granulations covered with a crust. The discharge is scanty and seropurulent. In some cases there is but one ulcer; in others there are two or several, and the fusion of ulcers produces a serpiginous outline. The ulcers do not heal, but gradually and steadily advance. Such ulcers are met with about the mouth, the genital organs, and the anus.

Tuberculosis Disseminata.—This occurs only in children; it is acute in onset and widespread. One type is polymorphic: spots, papules, pustules, and crusted ulcers existing, and lymphatic glands being enlarged. Another type follows one of the exanthemata and presents "a rough resemblance to flat lupus tubercles, to sluggish acne papules, and to lichen scrofulosum" (Stelwagon).

Tuberculosis Verrucosa.—*Anatomical tubercle*, the *verruca necrogenica* of Wilks, is due to local inoculation with tuberculous matter. It may be met

with in surgeons, the makers of post-mortems, leather-workers, and butchers, usually upon the backs of the hand and fingers. It consists of a red mass of granulation tissue having the appearance of a group of inflamed warts. Pustules often form.

Scrofulodermata or **tuberculous gummata.**—By scrofulodermata we mean chronic inflammations of the skin, the granulation-tissue product of which caseates, mixed infection occurs, and small abscesses, sinuses, or ulcers form. A *tuberculous ulcer* has a floor of a pale color, and has no granulations at all, or is covered with large, pale, edematous granulations. The discharge is thin and scanty. The ulcer is surrounded by a considerable zone of purple, tender, and undermined skin, which is apt to slough. When healing occurs, the skin puckers and usually inverts.

Lupus.—Lupus begins usually before the age of twenty-five, but is met with often in individuals in middle life. It is most usual upon the face, especially the nose. It is a very chronic and extremely destructive disease. Three forms are recognized: (1) *lupus vulgaris*, in which pink nodules appear that after a time ulcerate and then cicatrize partly or completely. These nodules resemble jelly in appearance; (2) *lupus exedens*, in which ulceration is very great; and (3) *lupus hypertrophicus*, in which large nodules or tubercles arise. Lupus may appear as a pimple, as a group of pimples, or as nodules of a larger size. The ulcer arises from desquamation, and is surrounded by inflammatory products which, by progressively breaking down, add to the size of the raw surface. The ulcer is usually superficial, is irregular in outline, the edges are soft and neither sharp nor undermined, the sore gives origin to a small amount of thin discharge, the parts about are of a yellow-red color, the edges are solid and puckered and scar-like and there is no pain. The sore is often crusted, the crusts being thin and of a brown or black color; it may be progressing at one point and healing at another; it is slow in advancing, but often proves hideously destructive. The scars left by its healing are firm and corrugated, but are apt to break down. Clinically it is separated from a rodent ulcer by several points. The rodent ulcer is deep, its edges are everted, and the parts about filled with visible vessels. It is not crusted, has not a puckered edge, its edges and base are hard and rarely show any tendency to healing.

Tuberculosis of Subcutaneous Connective Tissue.—In this form of tuberculosis tuberculous nodules form and break down (tuberculous abscesses). In the deeper tissues these abscesses are usually associated with bone, joint or lymphatic gland disease (see Cold Abscess, page 145).

Tuberculosis of the Mammary Gland.—(See page 152.)

Tuberculosis of Blood-vessels.—It is certain that bacilli in the blood or in tuberculous emboli may establish intravascular tuberculosis.

Tuberculosis of nerve is excessively rare. Tuberculous neuritis may arise in the course of general tuberculosis. A nerve lying in a tuberculous area may itself become tuberculous. It rarely does so, however. In fact, nerves resist infections though in the midst of them, and for this reason have been called the "aristocrats of the body."

Pulmonary Tuberculosis.—In adults the lungs are more commonly affected than any other structure. The lung affection may be primary or may be secondary to some distant tuberculous process. Pulmonary tuberculosis belongs to the province of the physician and requires no description here.

Tuberculosis of the Alimentary Canal.—A tuberculous ulcer of the lip occasionally arises, and may be mistaken for a cancer or a chancre. A tuberculous ulcer of the tongue is commonly associated with other foci of disease. Such ulcers are separated from cancer by their soft bases and edges and by the rarity of glandular enlargements, and from syphilitic processes by the therapeutic test. Confirmation of the diagnosis is obtained by cultivations and inoculations. Tubercle may affect the pharynx, palate, tonsils, and very rarely the stomach. It is thought that the acid gastric juice must protect the stomach from tubercle, because tubercle bacilli are frequently introduced into the stomach, but the organisms very rarely lodge and multiply in the stomach-wall.

Intestinal tuberculosis may follow pulmonary tuberculosis, but it may arise primarily in the mucous membrane of the bowel or result from tuberculous peritonitis. Intestinal tuberculosis causes diarrhea and fever, may resemble appendicitis, and may cause abscess and perforation. True tuberculous disease of the appendix occasionally occurs. Tuberculosis of the cecum is by no means as rare as we used to believe (page 861). Fistula in ano is frequently tuberculous, and when it is, the lungs are very often involved, the pulmonary lesion being usually primary (page 1009).

Tuberculosis of the Liver.—Tuberculous disease of the liver causes cold abscess or cirrhosis.

Peritoneal tuberculosis may be primary, infection having been by way of the blood, may be part of a diffused process, or may follow intestinal tuberculosis, the serous and muscular coats of the bowel having been at some point in contact or a follicular ulcer having perforated (Abbe). The germ may have entered by the Fallopian tube. It may be due to ovarian or Fallopian tuberculosis, or to ulceration of a tuberculous appendix. It usually causes ascites, tympany, and tumor-like formations composed of adherent bunches of bowel or omentum or distended mesenteric glands (page 870).

The **heart muscle** is rarely attacked by tuberculosis. In fact, valvular lesions of the left side of the heart actually protect the individual from pulmonary tuberculosis. Non-tuberculous endocarditis may arise in the course of a tuberculous process elsewhere. Tuberculous endocarditis does *very rarely* occur.

The **pericardium** may be attacked with primary tuberculosis, or the process may be secondary to pleural tuberculosis.

Tuberculosis of the pleura is not uncommon. Tuberculous pleurisy may be acute or chronic. In some instances mixed infection takes place and suppuration occurs. The tuberculosis may be primary, but is usually secondary to pulmonary tuberculosis, and may be due to direct extension or to rupture of an area of pulmonary softening. A primary pleurisy not due to traumatism is very apt to be tuberculous.

Tuberculosis of the brain induces meningitis and hydrocephalus (page 717).

Tuberculosis of the membranes of the spinal cord is seen alone or in association with tuberculous inflammation of the brain.

Tuberculous disease of fascia is common; in fact, fascia is peculiarly prone to infection. Fascia may be attacked primarily, and when it is, the disease is apt to spread rapidly and widely and to produce most disastrous

results. The elder Senn regards tuberculosis of the intermuscular septa of the thigh as a very grave condition, which, if extensive, demands amputation of the limb. Secondary tuberculosis of fascia is far more common than the primary form, the original focus of disease being in bone, joint, tendon-sheath, or lymph-gland.

Tuberculosis of muscle is rare. Instances of primary tuberculosis have been reported. Secondary tuberculosis is more common, but even this condition is rare, muscle seeming to have a high degree of resistance.

Tuberculous disease of bone is very common in youth, and usually a sprain or a contusion, which is oftener slight than severe, precedes any signs of the disease. The injury establishes a point of least resistance, and in the damaged area the bacilli are deposited and multiply, or else a latent area of tuberculosis is roused by the injury into activity. The organisms may be deposited directly from the blood, or may arrive in an embolism from a distant tuberculous focus (lung or lymph-gland), which embolus is caught in a terminal artery in the end of a long bone and causes a wedge-shaped infarction.

Tuberculous osteomyelitis, as a rule, begins just beneath the articular cartilage or in the epiphysis. There may be one focus, several foci or many foci in the same bone. The products of the tuberculous inflammation constitute tuberculous nodules which destroy the medullary tissue and hence cut off the nutrition of adjacent bone. Bone trabeculæ are destroyed, and tuberculous granulations take their place, and here and there small dead portions of bone trabeculæ lie as sequestra among the granulations. In some bones, for instance, the vertebræ and the bones of the corpus and tarsus, the tuberculous process spreads widely; in some it tends to remain localized. Tuberculous granulations may be absorbed, may be encapsuled, may be replaced by fibrous tissue, or may caseate (page 214). When an osseous tuberculous focus spreads and finally reaches the surface of the bone the stimulated periosteum produces new bone, while bone destruction is still going on within. Under such circumstances the bone enlarges and becomes spindle-shaped, as is seen in a phalanx, the seat of tuberculous osteomyelitis, the condition known as *spina ventrosa*.

Tuberculous disease of the joints is called "*white swelling*" and also *pulpy degeneration* of the synovial membrane. Joints are especially liable to tuberculosis in youth, although the wrist and shoulder not infrequently suffer in adult life. Joint-tuberculosis is often preceded by an injury. The tuberculous process may begin in the synovial membrane. Primary synovial tuberculosis is most often met with in the knee-joint. Usually the disease begins in the head of a bone, dry caries resulting, necrosis ensuing, or an abscess forming which may break into the joint.

Tuberculosis of lymphatic glands is known as "tuberculous adenitis." It is the most typical lesion of scrofula. The common antecedent of tuberculous adenitis of the neck is slight glandular enlargement as a result of catarrhal inflammation of the mucous membrane of the mouth. Tuberculous adenitis is most frequent between the third and fifteenth years. A person not of the tuberculous type may acquire tuberculosis of the glands, but the disease is unquestionably of much greater frequency in those who are recognized as predisposed to tuberculosis. Tuberculous glands may get well, may even

calcify, but usually caseate if left alone. Long after healing they may break down and soften (residual abscess of Paget). Tuberculous glands very frequently suppurate because of mixed infection. Though at first a local disease, tuberculous glands may prove to be a dangerous focus of infection, furnishing bacteria which are carried by blood or lymph to distant organs or throughout the entire system. Glandular enlargement is in rare instances widely diffused, but it is far more commonly localized. Enlargement of the cervical glands is most common. Tuberculous disease of the mesenteric gland is known as *tabes mesenterica*.

Cervical lymphadenitis may be confused with lymphadenoma. The former, as a rule, first appears in the submaxillary triangle; the latter, in the occipital or sternomastoid glands. Tuberculous glands weld together, they are apt to remain localized for a considerable time, and they tend to soften. They may be accompanied by other tuberculous manifestations. Lymphadenoma from the start affects many glands; it may arise simultaneously in several regions, although in some cases there is a distinct beginning in one region. Lymphadenoma shows very little tendency to suppurate, and does not break down except late in the course of the disease, and is accompanied by great debility and anemia. Malignant gland-tumors infiltrate adjacent glands and other structures, binding skin, muscles, and glands into one hard, firm mass.

Tuberculosis of tendon-sheaths (tuberculous tenosynovitis) is discussed on page 646.

Tuberculosis of the Kidney.—(See page 1114.)

Tuberculosis may attack the **Fallopian tubes, ovaries,** or **uterus.**

Tuberculosis of the urethra, prostate gland, seminal vesicles, and bladder is considered in the section on Regional Surgery.

Tuberculosis of the Testicle.—This disease is not rare. It is sometimes primary, but is usually preceded by tuberculosis of the kidney, bladder, or prostate. But one testicle is affected in the beginning, but the other gland is apt to be attacked later. The tuberculous mass softens, becomes adherent to the scrotum, and breaks or bursts, exposing the damaged testicle (*fungus of the testicle*). The cord is apt to be involved in tuberculosis of the testicle.

XIV. RACHITIS, OR RICKETS.

Rickets is a chronic disorder of nutrition arising during the early years of life (the first two or three) as a result of insufficient or of improper diet, aided and abetted in many cases by bad hygienic surroundings. A deficiency of fat and phosphate in the food or the use of a diet which, by inducing gastro-intestinal catarrh, prevents assimilation, causes rickets. It is characterized by incomplete osteogenesis and other nutritive failures. The disease is not common in nursing children unless breast-feeding has been unduly prolonged, and children fed upon artificial food are particularly apt to develop it. Holt says such diet is very deficient in fat and often in proteids, and contains an excess of carbohydrates ("Diseases of Infancy and Childhood"). J. Bland Sutton made some valuable experiments to indicate the injury done animals

by denying them natural diet. He fed lion cubs in the London Zoological Gardens on raw horse meat only and the animals developed rickets. The rickety animals rapidly recovered on feeding them with milk and powdered bones mixed with cod-liver oil. The disease is essentially a city malady, "being principally seen in children living in crowded tenements where the effects of improper food are most strikingly shown; yet even here the disease is rare in those who get a plentiful supply of good breast-milk" (Holt). Rickets must not be regarded as a bone disease. It is true the bones are affected, but so are various structures and organs, all of the disorders being due to an underlying nutritive defect. Some maintain that lactic acid, produced in the intestinal canal, causes bone inflammation, but most observers do not believe the bone changes are inflammatory. Children are very seldom born with rickets, but develop it later, the period of greatest liability being between the seventh month and the fifteenth month. So-called congenital rickets is usually sporadic cretinism. A child with rickets may become scorbutic (*scurvy rickets*). Some regard rickets as the result of an infection. Others think it results from thymus atrophy (Mendel).

Whatever may be the cause of rickets, the essential condition in the bones is an insufficient deposit of mineral matter in the new bone cells. The new bone is soft and vascular and bone lamellæ toward the medullary canal are actually absorbed. There is excessive proliferation of cartilage which results in enlargement. The proliferating and imperfectly ossified cells cause enlargements at the ends of long bones and at the sternal ends of the ribs and various bones bend and are distorted. The parietal bone bulges on each side, the fontanels remain long open; there may be unossified gaps in the occipital bone, membrane only filling them (*cranio-tabes*). There may be pigeon-breast, bent long bones, curved spine and distorted pelvis. The bones later may become firmly ossified in deformity. In rickets the spleen and liver are enlarged and the thymus is atrophied.

Evidences of Rickets.—The condition is one of general ill-health; the child is ill-nourished, pallid, flabby; it has a tumid belly and suffers from attacks of diarrhea and sick stomach; it is disinclined for exertion and has a capricious appetite; it is liable to night-sweats; enlarged glands are often noted, the teeth appear behind time, and the fontanels close late. In health the posterior fontanel closes in the second month and the anterior fontanel in the eighteenth month. In rickets the anterior fontanel is often open when the child is three years of age. The sutures are often open at the end of the first year. The head is square in shape, the cranial bones are thick, and areas of thickening known as bosses appear over the parietal bones. The head is large and the forehead bulges. The long bones become much curved, the upper part of the chest sinks in, curvature of the spine appears, and the pelvis is distorted. The ligaments are relaxed and lengthened and the joints are wobbly. The muscles are feeble and ill-developed. Infantile convulsions are common. Nocturnal restlessness and night terrors are the rule. Laryngismus stridulus and tetany may occur. Swelling appears in the articular heads of long bones, by the side of the epiphyseal cartilages, and in the sternal ends of the ribs, forming in the latter case *rachitic beads*. The lesions of rickets are due to imperfect ossification of the animal matter which is prepared for bone-formation, and the soft bones gradually bend. The swellings at the articular

heads are due to pressure forcing out the soft bone into rings. Rachitic children rarely grow to full size, and the disease is responsible for many dwarfs. Most cases recover without distinct deformity, but the time lost during the period when active development should have gone on cannot be made up, and some slight deficiency is sure to remain. Bowlegs, knock-knees, and spinal curvatures are usually rachitic in origin. The disease may be associated with scurvy, inherited syphilis, or tuberculosis. In appearance the rickety child is pot-bellied, pale and anemic, and usually fat and flabby, though occasionally thin. There is great liability to enlargement of the tonsils, gastro-intestinal catarrh, and bronchial catarrh. The blood is deficient in red corpuscles and hemoglobin, and sometimes there is leukocytosis. The disease lasts for many months and is usually recovered from. It does not directly produce death, but is a powerful indirect cause of infant mortality because it lessens resistance and predisposes to many diseases. It is almost always afebrile; rarely congenital; and in unusual cases known as late rickets develops between the fifth and tenth year. The so-called acute rickets is practically always scurvy (Holt). The victims of rachitis are very liable to fracture the bones from slight force and green-stick fractures are particularly prone to occur. After fracture of a rickety bone union is usually delayed.

Treatment.—The treatment consists in having the child live as much as possible in the open air and sunshine. Salt-water baths are useful. Sea air is very beneficial. Fresh food (milk, cream, and meat-juice) should be ordered. Cod-liver oil, syrup of the iodid of iron, arsenic, and some form of phosphorus are to be administered. It is absolutely necessary to improve the primary assimilation. Slight deformities of the extremities require no special treatment unless they increase. If the deformity is marked or is increasing, use braces; employ massage, manipulation, and faradism. Holt points out that by the time the child is two years of age the bones are so firm that the pressure of a brace cannot cure the deformity. Hence after this age braces are useless. Pronounced established deformities of the extremities are usually treated surgically. Kyphosis is treated by making the patient lie upon a hard bed without a pillow. The child sits up a few hours each day, the shoulders being held back and support applied to the body. In bad cases, during the time the child is erect it should wear a brace or plaster-of-Paris jacket. Daily manipulation, the child lying prone, is helpful. Friction and electricity to the spinal muscles do good.

Scorbutus (Scurvy).—This disease is rare to-day in adults, but was at one time very common among those who took long voyages, or who engaged in campaigns, or were the victims of sieges. Of recent years it is very uncommon, and has occurred chiefly among voyagers in the Arctic regions or those who were beleaguered. Some years ago I saw several cases in a large almshouse. It is important to remember that though scurvy is rare in adults, it is by no means uncommon in ill-nourished infants. (A most graphic picture of scurvy as it used to occur will be found in "A Voyage Around the World," by Lord Anson. Compiled by the Rev. R. Walter.)

Scurvy is a constitutional malady due to the consumption of improper diet, and especially to the employment of a diet characterized by the absence of vegetables.

The use of salt meat as a staple article seems to favor the production of

the disease. Garrod considered absence of potassium salt to be the real cause. Absence of variety in diet, bad water, poorly ventilated quarters, and insufficient exercise favor the development of the disease. Some believe that an organic poison derived from tainted food is responsible (Torup). A bacterial origin has been suggested by Berthenson, Babés, and others. Certain studies made in the Transvaal suggest the bacterial origin of scurvy. Myer Coplans ("Lancet," June 18, 1904) states that it occurred in those getting excellent rations and began as inflammation of the gums, the constitutional symptoms following. If the gum condition was early recognized and cured simply by cleanliness and antiseptics, that is, by pure local treatment, constitutional trouble did not develop.

Scurvy begins with weakness, drowsiness, muscular pains, and great susceptibility to cold. The skin is pallid or dirty white, and is occasionally mottled and often peels off. The patient is breathless on the slightest exertion. The pulse is excessively weak and slow. There is no fever. The gums may be tender and inflamed from the start, but in most cases they are not. After two or three weeks, usually the gums become tender, painful, and swollen, and bleed at frequent intervals; the breath becomes offensive, the teeth loosen and even drop out; subcutaneous hemorrhages take place, giving rise to petechiæ or extensive extravasations; the vision becomes dim; the urine becomes scanty and of low specific gravity; cutaneous vesicles form, rupture, and give rise to bleeding ulcers, and ulcers likewise arise from breaking down of blood extravasations; hemorrhages take place into and between the muscles, and in severe cases beneath the periosteum and into joints, and blood may flow from the nose, lungs, kidneys, stomach, and intestines. Deep hemorrhages are felt as hard lumps. Bleeding at an epiphyseal line may separate the epiphysis from the shaft. If an inflammation or ulceration arises at any point, fever is observed. It was observed by DeHaven, who commanded the Grinell expedition in search of Sir John Franklin, that scurvy causes old and soundly healed wounds to ulcerate. The same observation was made years before in Lord Anson's voyage. A sailor of the "Centurion" had been wounded fifty years before at the battle of the Boyne. He developed scurvy and the old wound opened. Most cases of scurvy get well under proper treatment, but complete recovery is not attained for a long time. Sudden death is liable to occur if any exertion is made.

Captain Cook succeeded in preventing scurvy among his sailors by providing plenty of fresh water; gaurding them against fatigue, wet, and extremes of heat and cold; attending to cleanliness and ventilation, and stimulating cheerfulness. This great navigator lost no men from scurvy. After the time of Captain Cook, the British Admiralty, acting on the suggestions of Lind and Blane, provided ships with lime-juice or lemon-juice with the most beneficial results in preventing the disease. Scurvy is prevented at the present time by employing a proper diet and by maintaining cleanliness and hygienic conditions.

The following agents are believed to be especially useful as preventatives: fresh meat, lemon-juice, cider, vinegar, milk, eggs, onions, cranberries, cabbages, pickles, potatoes, and lime-juice. When the disease develops, give vinegar, lemon-juice, onions, scraped apples, cider, nitrate of potassium, whiskey or brandy, and plenty of nourishing food. Antiseptic mouth-washes

are necessary and strychnin is a valuable stimulant to the circulation. Sleep must be secured and ulcers are treated by antiseptic dressings and compression.

Infantile scurvy or **Barlow's disease** may exist alone or with rickets (*scurvy rickets*). It occurs most often in the children of the well-to-do, those who have been brought up on artificial foods. It occurs between the eighth and eighteenth months of life. The child is anemic, suffers from gastro-intestinal disorders, spongy and bleeding gums, weakness of the legs, general muscular tenderness, night-sweats, and often febrile attacks (Rotch), bleeding from the nose, bleeding beneath the skin (blue spots), bloody urine and stools, bleeding beneath the periosteum, into joints, viscera, or muscles. In some cases hematuria is the first and perhaps the only symptom (J. Lovett Morse, "Jour. Am. Med. Assoc.," Dec. 17, 1904). A subperiosteal hemorrhage is very dense, is tender, is fusiform in outline, and does not fluctuate. It is sometimes mistaken for sarcoma. In one case seen by the author a hemorrhage beneath the periosteum of the femur was mistaken for a sarcoma. The limb attacked is flexed, and the child will not move it. Separation of an epiphysis may result from hemorrhage between it and the bone. Infantile scurvy is often unrecognized. If promptly treated, recovery is the rule, otherwise death may occur from exhaustion.

Treatment.—Keep the child quiet in bed and give liberal amounts of cow's milk and beef-juice. Administer orange-juice, grape-juice, scraped apples, and tonics. To children over one year of age give potatoes. Antiseptic mouth-washes are necessary.

XV. CONTUSIONS AND WOUNDS.

Contusions.—A contusion or bruise is a subcutaneous laceration, due to the application of blunt force, the skin above it being uninjured or damaged without a surface-breach and blood being effused. Punches, kicks, blows from a blackjack, etc., cause contusions. In intra-abdominal contusions the skin of the abdomen is frequently not damaged. In contusions of structures overlying a bone the skin suffers with the deeper structures. If a large vessel is ruptured, hemorrhage is profuse and much blood gathers in the tissue. If only small vessels suffer, hemorrhage is moderate. An *ecchymosis* is diffuse hemorrhage over a large area, the blood lying in the spaces of the subcutaneous or submucous areolar tissue. A very small ecchymosis is known as a *petechia;* a very large ecchymosis is called a *suffusion* or *extravasation.* A *hematoma* is a blood-tumor or a circumscribed hemorrhage, the blood lying in a distinct cavity in the tissue. In extremely severe contusions tissue vitality may be destroyed or so seriously impaired that gangrene follows. Suppuration rarely occurs, but occasionally does so, and is most apt to in a drunkard or a person of dilapidated constitution. When hemorrhage arises in the tissues after a contusing force it soon ceases unless a very considerable vessel is ruptured. The arrest of hemorrhage is brought about by the resistance of the tissues, the contraction and retraction of the vessels, coagulation of blood, and in some cases of severe injury coagulation is favored by syncope. Blood in the tissues, as a rule, soon coagulates, the fluid ele-

ments being absorbed and the red corpuscles breaking up and setting free pigment, which pigment may be carried away from the seat of injury or may crystallize and remain there as hematoidin. In some cases inflammation occurs about the extravasated blood, a capsule of fibrous tissue being formed, and the blood being slowly absorbed, or the fluid elements remaining unabsorbed (*blood-cyst*), or the blood becoming thicker and thicker, finally calcifying. Blood in serous sacs (joints, pleura, pericardium) coagulates very slowly. As blood is being absorbed it undergoes chemical changes and color-changes ensue, the part being at first red and then becoming purple, black, green, lemon, and citron. The stain following a contusion is most marked in the most dependent area. After a bruise of the periosteum a blood-clot forms, much tissue-induration occurs, and a hard edge can be detected by palpation at the margin of the clot.

Symptoms.—The symptoms are tenderness, swelling, and numbness followed by some aching pain or a feeling of soreness. The pain rarely persists beyond the first twenty-four hours. Cutaneous discoloration appears quickly in superficial contusions, but only after days in deep ones. In some regions—the scalp, for instance—it can scarcely be detected; in others, as in the eyelid and vulva, discoloration is early, widespread, and marked. Discoloration and swelling are very marked in regions where loose cellular tissue abounds (eyelids, prepuce, scrotum). The discoloration is at first red, and becomes successively purple, black, green, lemon, and citron. The swelling is primarily due to blood, and is added to by inflammatory exudation. In a more severe contusion a hematoma may form. A recent hematoma fluctuates, but gradually, because of cell-proliferation, the edge becomes hard and the center continues to fluctuate. The mass gradually grows smaller and finally disappears. A subperiosteal hematoma of the scalp may be mistaken for depressed fracture of the skull. Any form of hematoma of the scalp may be mistaken for an abscess, but differs from it in the absence of inflammatory signs. It occasionally, though rarely, suppurates. In a case in which suppuration occurs an abrasion, which may be very minute, often exists on the skin. In any severe contusion there is considerable and possibly grave, or even fatal, shock.

Treatment.—In a severe injury bring about reaction from the shock. Local treatment consists in rest, elevation, and compression to arrest bleeding, antagonize inflammation, and control swelling. Cold is useful early in most cases, but it is not suited to very severe contusions nor to contusions in the debilitated or aged, as in such cases it may cause gangrene. In very severe contusions employ heat and stimulation. When inflammation is subsiding after a contusion, compression and inunctions of ichthyol should be employed. Massage and passive motion are imperatively needed after contusion of a joint. If the amount of blood is very large, massage must not be used because it may cause embolism or fat-embolism. If a distinct cavity exists, aspiration or incision lessens the danger of fat-embolism. A contusion should never be incised unless the amount of blood is large and a distinct cavity exists, or hemorrhage continues, or infection takes place, or a lump remains for some weeks, or gangrene is threatened. For persistent bleeding freely lay open the contused area, turn out clots, ligate vessels, insert drainage-strands or a tube, and close the wound. If gangrene is feared, make incisions and apply heat to the part. If a slough forms, employ antiseptic fomentations.

The constitutional treatment for contusion, after the patient has reacted from shock, is the same as that for inflammation. (See Abdomen, etc.)

Wounds.—A wound is a breach of surface continuity effected by a sudden mechanical force. Wounds are divided into open and subcutaneous, septic and aseptic, incised, contused, lacerated, punctured, gunshot, stab, and poisoned wounds.

The **local phenomena of wounds** are pain, hemorrhage, loss of function, and gaping or retraction of edges.

Pain is due to the injury of nerves, and it varies according to the situation and the nature of the injury. It is influenced by temperament, excitement, and preoccupation. It may not be felt at all at the time of the injury. At first it is usually acute, becoming later dull and aching. In an aseptic wound the pain usually remains slight, but in an infected wound it always becomes severe.

The nature and amount of *hemorrhage* vary with the state of the system, the vascularity of the part, and the variety of injury.

Loss of function depends on the situation and extent of the injury.

Gaping or *retraction of edges* is due to tissue-elasticity, and varies according to the tissues injured and the direction, nature, and extent of the wound.

The **constitutional condition** after a severe injury is a state known as *shock.*

Shock.—The name shock was introduced in 1795 by James Latta to designate the condition ensuing upon severe injury. (See G. C. Kinnaman, in "Annals of Surg.," Dec., 1903.) Shock is a sudden depression of the vital powers arising from an injury or a profound emotion acting on the nerve-centers and inducing exhaustion or inhibition of the vasomotor mechanism. Exhaustion is gradually induced; inhibition is suddenly produced. By over-stimulation of sensory nerves violent impressions are conveyed to the nerve-centers, the vasomotor center is exhausted or inhibited, vaso-constrictor power is lost, the arteries and capillaries are depleted or nearly emptied of blood, and the blood is largely transferred to the veins. The blood-pressure is lowered, the cardiac action is impaired, the respiratory action is impeded, and quantities of dark-colored blood gather in the somatic veins, but especially in the veins of the splanchnic area. (See the masterly study of "Surgical Shock" by Crile.) In shock the abdominal veins are greatly distended and the other veins of the body may also be overfull, the arteries contain less blood than normal, and an insufficient amount of blood is sent to the heart and to the vital centers in the brain. In other words, in shock there is a deficiency in the circulating blood. The term *collapse* is used by some to designate a severe condition of shock, and is employed by others as a name for a condition of shock produced by mental disturbance rather than by physical injury. Crile regards collapse as inhibition of the vaso-motor center, in contrast to shock, which is exhaustion of the center. As a matter of fact, shock and collapse are often both present. That the bombardment of the nerve-centers by a tumult of peripheral impressions causes shock is shown by the fact that if the nerves from a part are thoroughly cocainized so that they will not transmit sensation, operation upon the part produces practically no shock. Crile calls such cocainization the introduction of a *physiological block.* Shock may be slight and transient, it may be severe and

prolonged, and it may even produce almost instant death. Sudden death from shock is due to reflex stimulation of the pneumogastric nuclei and arrest of cardiac action. It is known as *death by inhibition.* Shock is more severe in women than in men, in the nervous and sanguine than in the lymphatic, in those weakened by suffering than in those who are strangers to illness. It is predisposed to by fear, by disease of the kidneys, diabetes, chronic cardiac disease, and alcoholism. Injuries of nerves, of brain, of the intrathoracic viscera, of the intra-abdominal viscera, of the urethra, or of the testicle produce extreme shock. Anything which extracts the body-heat favors the development of shock (exposure to cold air, insufficient covering, chilling the body by solutions or wet towels). Cerebral concussion is shock plus other conditions. Sudden and profuse hemorrhage causes shock; so does prolonged anesthetization. Great shock may occur after the removal of a large tumor or a quantity of fluid from the abdomen. In such a case shock is brought about by the sudden removal of pressure and the consequent rapid distention of intra-abdominal veins. Exposure of tissue and vital parts to air aggravates shock.

Symptoms.—The symptoms of ordinary shock (*torpid* or *apathetic shock*) are subnormal temperature; irregular, weak, rapid, and compressible pulse; cold, pallid, clammy, or profusely perspiring skin; and shallow and irregular respiration. Consciousness is usually maintained, but there is an absence of mental originating power, the injured person answering when spoken to but volunteering no statements and lying with partly closed lids and expressionless countenance in any position in which he may be placed. The answers to questions though apparently intelligent are utterly unreliable. The pupils are dilated and react but slowly to light. The sphincters are relaxed. Pain is slightly or not at all appreciated. Nausea is absent and vomiting may, as in concussion, presage reaction. Gastric regurgitation, after a considerable duration of shock, is not unusual, and is a bad omen. Shock is not rarely followed by suppression of urine. Whereas the victim of shock is usually stupid and indifferent, he may become delirious. If delirium arises, the condition is very grave. Travers called shock with delirium *erethistic* or *delirious shock.* As a matter of fact, such a state is not genuine shock but is either a traumatic or a toxic delirium. It is usually due to uremia or sepsis. Delirious shock is seen after a person has been bitten by a poisonous snake. Many years ago Travers described a *secondary* or *delayed form* of shock, which comes on several hours after an injury or violent emotional disturbance. This form of shock is seen not unusually in those who have passed through a railroad accident. It may be a sign of hemorrhage, and is sometimes met with after the administration of ether or chloroform. The statements made by a person who has recovered from a severe shock are always unreliable as to events which occurred while shock existed, and are often doubtful as to the details of the accident. Not unusually the memory of the accident is perverted or even destroyed.

Diagnosis.—Concealed hemorrhage is difficult to differentiate from shock. It produces impairment of vision (retinal anemia), irregular tossing, frequent yawning, great thirst, nausea, and sometimes convulsions. In shock the hemoglobin is unaltered; in hemorrhage it is enormously reduced (Hare and Martin). In hemorrhage recurrent attacks of syncope are met with. In

pure shock such attacks do not occur. In concealed hemorrhage the abdomen may exhibit physical signs of a rapidly increasing collection of fluid. Shock and hemorrhage are often associated. The essential characteristic of shock is rapid onset, which separates it distinctly from exhaustion. It arises at a much earlier period after an injury than does fat-embolism.

The Prevention of Shock in Operations.—Examine the patient with care before operating, giving special attention to the condition of the kidneys. The amount of urine passed and the amount of urea it contains should always be determined when possible. The amount of urea should be estimated from

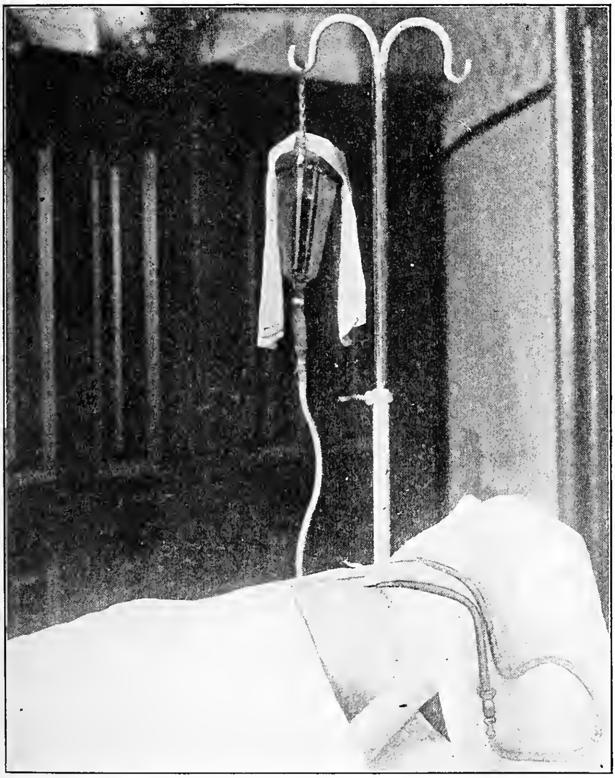


Fig. 90.—Subcutaneous saline infusion (Senn).

the twenty-four hours' urine. The normal amount of urine in the twenty-four hours is about fifty ounces and the normal amount of urea 2 per cent. Less urea is significant of danger from shock and subsequent kidney complications. If the condition of the patient leads us to fear that there will be dangerous shock, do not purge him severely before operation, and just previous to operation give a rectal injection of hot saline fluid and a hypodermatic injection of $\frac{1}{100}$ of a grain of atropin. It is also a good plan in some cases to give a hypodermatic injection of gr. $\frac{1}{8}$ of morphin twenty minutes before operation. It tranquillizes the patient and less ether will be needed to anesthetize him. Examine the patient thoroughly and prepare him carefully beforehand and

decide if he should take a general anesthetic at all, and, if so which one. In some cases a local anesthetic should be used, for instance, some cases of typhoid perforation and strangulated hernia.

Occasionally the nerves from the damaged part should be infiltrated with cocain (Crile). This prevents the ascent of peripheral impressions, makes what Crile calls a "physiological block," and so prevents shock. After this infiltration a limb can be amputated below the infiltrated area without pain and without depression of the vital powers. In some few cases in which we fear shock spinal anesthesia is used; in others scopolamin and morphia. If a general anesthetic is used it must be skillfully given and not a drop is given beyond the amount necessary to maintain thorough anesthesia. Cover every part but the field of operation with hot blankets and put cans of hot water about the patient, or put him on a bed composed of hot-water pipes covered with blankets. Prevent bleeding with the greatest possible care. Operate as rapidly as is consistent with safety and thoroughness. If shock develops during an operation hasten on the work, lessen the amount of ether, and apply active treatment. Return the patient to bed as soon as possible and without exposure in cold halls or a windy elevation. Occasionally it becomes necessary to suspend an operation in order to prevent death on the table.

Treatment.—In treating ordinary apathetic shock raise the feet and lower the head, unless this position causes cyanosis. At least place the head flat and the body recumbent. Wrap the patient in hot blankets and surround him with hot bottles, hot bricks, hot-water bags or cans of hot water. Always wrap a can, a bottle, or a bag in flannel, to avoid burning the patient. Ordinary stimulants seem of but little value and drugs given by the stomach are not absorbed. Salt solution may be thrown into a vein (*intravenous infusion*), may be given by the rectum (*enteroclysis*), or subcutaneously (*hypodermoclysis*). Intravenous infusion does good, but, unfortunately, the benefit is very temporary except in cases associated with hemorrhage. In hemorrhage it should always be given. The operation of intravenous infusion is described on page 400, and the manner of incising the vein and inserting the tube is shown in Fig. 91. Crile maintains that the only way "to increase and sustain the blood-pressure when the vasomotor center is exhausted" is to "create a peripheral resistance

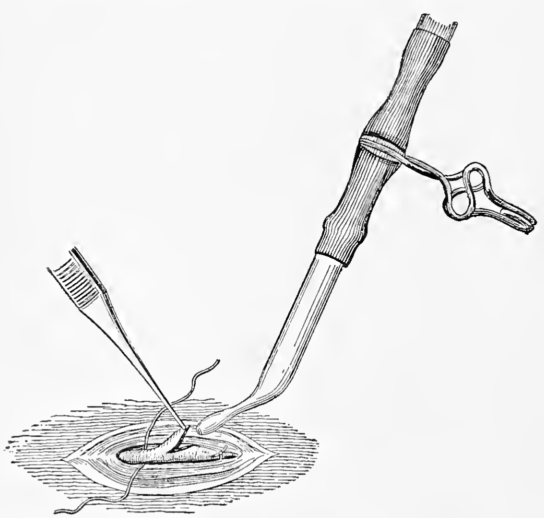


Fig. 91.—Intravenous saline infusion. Manner of incising vein and inserting glass tube (Senn).

either by a drug acting on the blood-vessels themselves or by mechanical pressure."* The proper drug to use is adrenalin chlorid. Because of the rapidity with which this drug is oxidized, Crile gives it intravenously and continuously, using a solution of a strength of from 1 in 50,000 to 1 in 100,000 in salt solution. It is given slowly from a buret, "the rate of flow being controlled by a screw-cock attached to the rubber tube." Crile also places the patient in a rubber suit and distends the suit by means of an air pump and thus obtains equable pressure upon the cutaneous surface and an increase of peripheral vascular resistance. Since the publication of Crile's paper I have used adrenalin chlorid in shock in preference to strychnin, and am satisfied that it is greatly superior to the latter drug. A preparation of a solution of adrenalin chlorid is on the market which can be readily added to salt solution until the proper degree of dilution is obtained. A teaspoonful of this solution contains the drug in the proportion of 1 part to 1000, and this amount should be added to 1 liter of salt solution. The use of hot and stimulating rectal enemata is important. The rectum may absorb fluids when the stomach refuses to do so. Enemata of hot normal salt solution are beneficial (*enteroclysis*). The tube is carried to the sigmoid flexure and the injection is introduced so as to distend the colon. *Hypodermoclysis* is given as follows: Insert an aspirator tube into the cellular tissue of the loin, scapular region, or under the mamma, cleansing the part first. The tube is attached to a fountain syringe, which is filled with normal salt solution, and is hung at a height of two or three feet above the bed (Fig. 90). In an hour's time a pint or more of fluid will enter the tissue and be absorbed. It is the custom to give hypodermatic injections of ether, brandy, strychnin, digitalis, or atropin, or inhalations of amyl nitrite. Crile has demonstrated experimentally that strychnin is perfectly futile in pure shock and may actually aggravate the condition. In collapse it is of some value. We believe this statement is true clinically. Strychnin goads a heart to increased action when that organ has not sufficient blood passing into it to enable it to firmly and strongly contract; the use of strychnin in shock has been compared by Hare to beating a dying horse to make it pull. I believe that atropin is of great benefit in shock, especially if the skin is very moist. This drug, according to my colleague, Prof. Hobart A. Hare, is a sedative to the vagus; but what makes it particularly valuable is that it acts upon the vasomotor system, combats the dilatation of the blood-vessels, maintains vascular tone, prevents stagnation of blood in any vessels, and increases the amount of moving blood. If the skin is very moist, atropin is particularly indicated. Senn recommends the hypodermatic injection of sterile camphorated oil, a syringeful every fifteen minutes until reaction begins. Inhalation of oxygen is often of much service, and artificial respiration may be necessary. Opiates are contraindicated in shock. Mustard plasters should be placed over the heart, spine, and shins. A turpentine enema is useful. An enema of hot coffee and whiskey is valuable. In severe cases of shock, bandage the extremities. Bandaging for the relief of shock is called *autotransfusion*. This procedure increases peripheral resistance and enables the body to utilize to the best advantage the small amount of circulating blood, and sends most of it to the brain, where it will maintain the activity of the vital centers and keep up cir-

* George Crile, in Boston Med. and Surg. Jour., March 5, 1903.

culation and respiration. For this purpose ordinary muslin bandages may be used, or gauze bandages, or the bandages of Esmarch. Crile's rubber suit accomplishes the object more satisfactorily than does bandaging the extremities. Abdominal massage helps drive out the imprisoned blood, and after massage sets free the abdominal blood apply a compress and binder. In serious cases artificial respiration and stimulation of the diaphragm with a galvanic current may be used. If shock comes on during an operation, the operation must be hurried or even abandoned, and proper treatment must be instituted at once. The anesthetist should give very little ether when shock becomes at all evident. Should we operate during shock? We should only do so when death without instant operation is inevitable. We must operate, if it is necessary to do so, to arrest hemorrhage, to relieve strangulated hernia, intestinal obstruction, obstruction of the air-passages, compound fractures of the skull, extravasated urine, or intraperitoneal extravasations from ruptured viscera. If hemorrhage can be temporarily controlled by pressure or a clamp, so much the better, and the permanent arrest can be effected after the reaction from shock. It is not wise, in the author's opinion, to amputate during shock. A tourniquet or Esmarch bandage should be applied, and attempts be made to bring about reaction, and when reaction is obtained the amputation should be performed. It is only just to say that some eminent surgeons oppose this rule. Roswell Park says that "shock is often alleviated by the prompt removal of mutilated limbs which, when still adherent to the trunk, seem to perpetuate the condition." The same teacher believes in operating at once upon severe compound fractures.* After every operation keep careful watch upon the amount of urine passed, see to it that the patient takes sufficient fluid, and if the urine becomes scanty put a hot-water bag over the kidneys, give diuretics by the mouth, secure cutaneous activity, give saline purgatives, and administer hot saline enemata. If the condition is not soon benefited, the custom is to infuse hot saline fluid into a vein. I am doubtful if intravenous infusion of saline fluid is beneficial in suppression, and I even fear it may do harm (see the studies of Widal, Marie and Crouzon, Merklen, and others). In urinary suppression following accident or surgical operation (post-operative suppression or anuria) the condition is so dreadfully grave that it is justifiable to expose each kidney and split the capsule in order to relieve tension and in the hope of thus abating congestion. *Post-operative suppression of urine* is almost invariably fatal. Delayed shock is treated in the same manner as apathetic shock if hemorrhage can be excluded. If hemorrhage is the cause, the bleeding must be arrested. If delirious shock is due to sepsis, the treatment is that of sepsis. If it is a nervous delirium give morphin and other sedatives. If due to uremia, the treatment is obvious.

Fat-embolism.—(See page 191.)

Fever.—(See Fevers, page 123.)

Treatment of Wounds.—All wounds, other than those made by the surgeon, are regarded as infected. The rules for treating such wounds are: (1) arrest hemorrhage; (2) bring about reaction; (3) remove foreign bodies; (4) asepticize; (5) drain, coaptate the edges, and dress; and (6) secure rest to the part and combat overaction of the tissues. Constitutionally, allay pain, secure sleep, maintain the nutrition, and treat inflammatory conditions.

*Park's "Surgery by American Authors."

Arrest of Hemorrhage.—To arrest hemorrhage the bleeding point must be controlled by an Esmarch band or digital pressure until ready to be grasped with forceps; it is then caught up and tied with catgut or aseptic silk. Slight hemorrhage ceases spontaneously on exposure of the bleeding point to air, and moderate hemorrhage ceases permanently after the temporary application of a clamp. An injured vessel when not of the smallest size must be ligated, even if it has ceased to bleed. Capillary oozing is checked by hot water and compression. If a large artery is divided in a limb, apply a tourniquet before ligating (see Wounds of Vessels).

Bringing about of Reaction.—(See Shock.)

Removal of Foreign Bodies.—Remove all foreign bodies visible to the eye (splinters, bits of glass, portions of clothing, gun-wadding, grains of dirt, etc.) with forceps and a stream of corrosive sublimate solution, sterile water, or normal salt solution. In a lacerated or contused wound portions of tissue injured beyond repair should be regarded as foreign bodies and be removed with scissors.

Cleaning the Wound.—To clean the wound shave the surrounding area, if it is hairy; scrub the surface about the wound with ethereal soap, green soap, or castile soap, wash with water, scrub with alcohol, and then with corrosive sublimate solution (1 : 1000). An accidental wound is infected, and must be well washed out with an antiseptic solution. A clean wound made by the surgeon need not be irrigated; in fact, irrigation with an antiseptic fluid leads to necrosis of tissue, causes a profuse flow of serum, and necessitates drainage. If clots have gathered in a wound, they must be removed, as their presence will prevent accurate coaptation of the edges. In an infected wound they are washed out with a stream of corrosive solution. In a clean wound they are washed out with hot salt solution. If dirt is ground into a wound, as is often seen in crushes, pour sweet oil into the wound, rub it into the tissues, and scrub the wound with ethereal soap. The oil entangles the dirt, and the soap and water remove both oil and dirt. After the rough cleansing irrigate with corrosive sublimate solution. In some cases, especially in bone-injuries, it is necessary to scrape the wound with a curet. If a fissure of the skull is infected, enlarge the fissure with a chisel in order to clean it. In a badly infected wound one of the most valuable agents for use in producing disinfection is pure carbolic acid. After cleaning the wound, it is necessary in certain regions to examine in order to determine if tendons or considerable nerves have been cut. If such structures have been divided, they must be sutured with fine silk, chromic gut, or kangaroo-tendon.

Drainage, Closure, and Dressing.—Superficial wounds require no special drainage, as some wound-fluid will find exit between the stitches and the rest will be absorbed. A large or deep wound requires free drainage for at least twenty-four hours by means of a tube, strands of horsehair, silk, or catgut, or bits of iodoform gauze. An infected wound must invariably be drained. Good drainage may, to a considerable extent, compensate for imperfect antisepsis. If capillary drains be employed, apply a moist dressing. Approximate the edges with interrupted sutures of silk or silkworm-gut if the wound is deep and considerable tension is inevitable. Catgut is used for superficial wounds and for those where tension is slight. If there is decided tension,

silver wire may be used. In very deep wounds buried sutures must be used. These sutures may consist of absorbable material (kangaroo-tendon or catgut) or unabsorbable material (silver wire). If the wound is infected, dress with warm, moist antiseptic gauze. If it is not infected, dress with dry sterile gauze. The custom once was to cover even dry gauze with a rubber dam to diffuse the fluids, but we now prefer to omit the rubber dam and use plentiful dressings. A dry dressing absorbs wound fluids quickly and is less likely to become infected. Change the dressings in twenty-four hours, or sooner if they become soaked with discharge. Dressings are changed for

A *B*

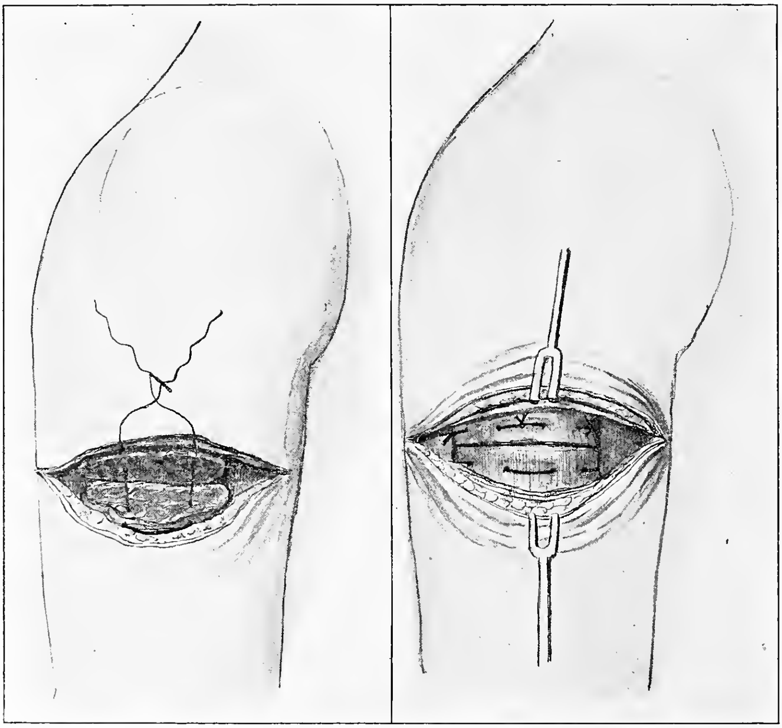


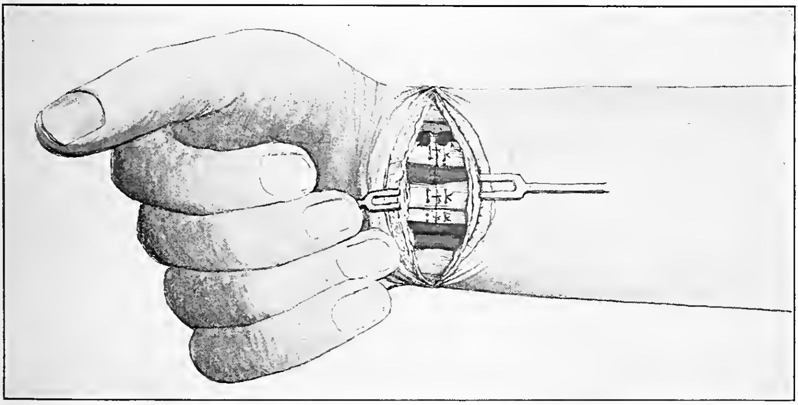
Fig. 92.—Muscle suture: *A*, Transverse wound of biceps muscle, showing marked retraction of muscle-ends and mattress suture in place; *B*, muscle suture completed (Senn).

cause, but not according to scheduled time. They must, of course, be changed when they become soaked with wound-fluid, and soaking may occur in a few hours, but may not occur for days. As long as the temperature remains normal, and the wound free from pain, if the dressing is not wet with discharge, it can be left in place unless removal is necessary to take out a drainage-tube. If pus forms, open the wound at once. Many surgeons sprinkle wounds before approximation and wound surfaces after approximation with a drying-powder. These powders are of great use in infected wounds, but are not necessary in clean wounds. Among the substances employed are salicylic acid, boric acid, calomel, acetanilid, aristol, iodoform, subiodid of bismuth,

and glutol. In large wounds which cannot be approximated it is occasionally advisable to skin-graft by Thiersch's method. A small wound which cannot be sutured is dusted with an antiseptic powder and dressed. A granulating wound is dressed as is a healing ulcer. A sloughing wound is opened, is dusted with iodoform or acetanilid, and is dressed with hot antiseptic fomentations.

Rest.—Severe wounds require the confinement of the patient to bed. Bandages, splints, etc., are used to secure rest. The methods of combating inflammation have previously been set forth.

Constitutional Treatment.—Bring about reaction from depression, but prevent undue reaction. Feed the patient well, stimulate him if necessary, attend to the bowels and bladder, secure sleep, and allay pain. Watch for complications, namely, inflammation, suppuration, gangrene, tetanus, erysipelas, suppression of urine, and pneumonia. Observe the temperature closely; it may be a danger-signal of urgent importance.



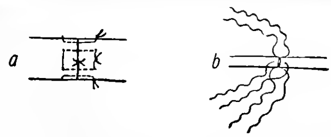


Fig. 93.—Suturing of tendons and nerves in incised wounds: *a*, Primary tendon suture; *b*, primary nerve suture (Senn).

Incised Wounds.—An incised wound is a clean *cut* inflicted by an edged instrument. Only a thin film of tissue is so devitalized that it must die. These wounds have the best possible chance of union by first intention.

The pain may be very severe; but if the instrument is sharp and used quickly it may be trivial. The pain is less severe than that caused by some other varieties of wounds. The acute pain does not last long, and is followed by smarting. The hemorrhage is profuse, varying, of course, with the region cut. Bleeding from the scalp is violent, because there are numerous vessels which lie in fibrous tissue and cannot retract nor contract. The edges of incised wounds retract because of tissue-elasticity, and the wound "gapes." If the skin or fasciæ are divided at a right angle to the muscle beneath, there is wide gaping. If the cut is parallel to the muscle-fibers, the gaping is slight.

When the skin is violently pulled upon, it tends to split in a certain line. Langer and Kocher speak of this as the line of cleavage, and point out the direction of these lines in various situations. A cut across the line of cleavage

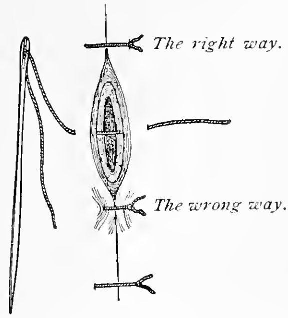


Fig. 94.—The interrupted suture (after Bryant).

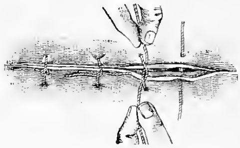


Fig. 95.—Tying an interrupted suture. The knot is placed to the *side* of the wound as shown in Fig. 94.

Fig. 96.—Continuous suture.

is followed by wide gaping. A cut in the direction of the line of cleavage produces slight gaping, and is followed by a trivial scar.

When a muscle is cut across, the wound edges widely separate. When a tendon is completely cut across, extensive separation occurs.

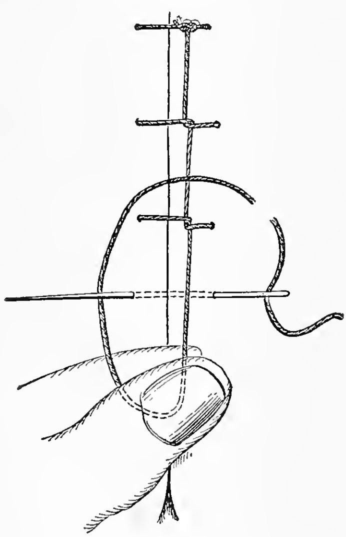


Fig. 97.—Ford's suture: a square knot, a single knot, a double or friction knot, and the first method of passing the needle to tie a single knot immediately.

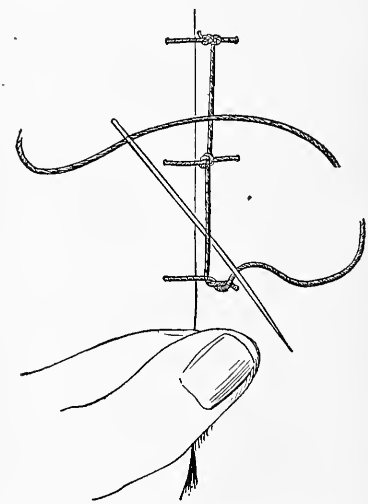


Fig. 98.—Ford's suture: showing two square knots, a single knot, and the method of completing a square knot.

An incised wound can be thoroughly inspected, all divided structures can be identified, foreign bodies can be easily removed, and disinfection can be satisfactorily carried out.

Treatment.—According to general principles. Arrest hemorrhage, asepticize, etc.

Examine the wound carefully to see if a nerve, a tendon, or a muscle is divided, and if such injury is discovered, suture at once (Figs. 92 and 93). If the wound is extensive or deep, it may be necessary to use buried sutures in order to keep the sides of the wound in contact. If the surface of a wound is approximated, but the depths are not, the dead space or cavity becomes filled with fluid, and infection almost certainly occurs. If buried sutures have not been used, such a cavity must be obliterated by the judicious application of pressure upon the surface. This is secured by the adaptation of a mass of loose or fluffed-up gauze, and the firm application of a bandage or binder. An incised wound is usually closed with interrupted sutures (Figs. 94 and 95). In adjusting the sutures, see that the edges of the wound are not inverted, but are neatly adjusted, and that the knot does not lie upon the wound line, but rests to the side of it. Tie the stitches firmly but not tightly. If a stitch is tied too tightly it will make a furrow, as shown in Fig. 94, and undue tightness is sure to cause necrosis, and is often productive of a stitch-abscess. A silk suture and a catgut suture should be tied with the reef knot; a suture of silkworm-gut should be tied with a surgeon's knot. If a wound is on the face, particular care must be employed in closing it, in order to limit the amount of disfigurement. In a clean wound stitches can, as a rule, be removed in from six to eight days. In a large wound one-half the stitches are removed at one sitting, and in a day or two the rest are removed. Stitches are promptly removed if they begin to cut out or if infection occurs.

The old continued suture is rarely used for skin-wounds at the present time. This suture is employed to suture the dura after division, to suture the two layers of pleura together before an abscess of the lung is opened, to suture the peritoneum after laparotomy, and to suture the mucous membrane after certain operations upon the stomach. The continued suture is shown in Fig. 96. A continuous suture knotted after each emergence was devised by Ford. It is very useful in suturing the parietal peritoneum (Figs. 97 and 98).

Halsted's subcuticular stitch (Fig. 99) makes a most perfect closure of the skin-wound, and is followed by the smallest possible scar. It is only used in wounds which are almost certainly clean, as those made by the surgeon, and in wounds which do not require drainage. The suture material should be of silver wire caught upon a curved Hagedorn needle or silkworm-gut carried by a long, straight, round needle. The suture is passed through the corium on each side of the wound, as shown in Fig. 99. The curved needle must be held in the bite of a needle-holder. When the suture has been passed the ends are pulled upon, and the skin-wound closes neatly.

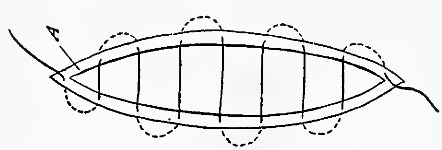


Fig. 99.—Halsted's subcuticular suture. *A* is the true skin.

Halsted's suture does not penetrate the cuticle; hence, in passing it the white staphylococcus is not carried through stitch-holes and into the wound, an accident which might be followed by infection of a

stitch-hole or even of the wound. When it is desired to withdraw this suture, take one end in the bite of a forceps, cut it off short with scissors, and pull steadily upon the other end.

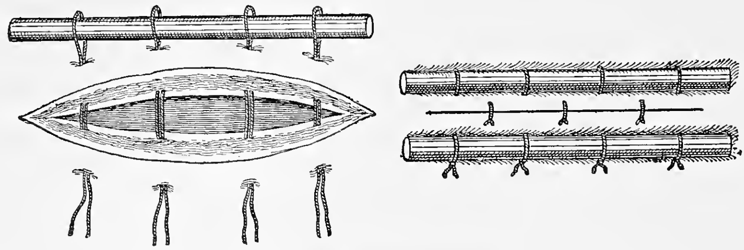


Fig. 100.—The quilled suture.

In very deep wounds or wounds in which there is much tension after approximation the quilled suture (Fig. 100) or the button suture (Fig. 101) may be used. The twisted suture, or harelip suture, is shown in Fig. 102.

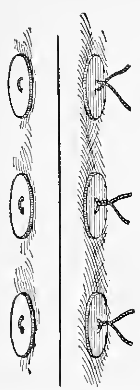


Fig. 101.—Button suture.

Problems of drainage, dressing, etc., are discussed on pages 70, 71, and 72.

If infection occurs, the wound becomes swollen, tender, painful, and discolored, and the temperature of the patient soon becomes elevated. In such a condition cut the stitches, disinfect, and drain.

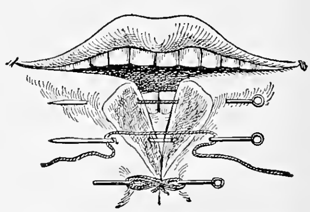


Fig. 102.—The twisted suture.

Wounds of Mucous Membranes.—If the surgeon intends to inflict a wound upon a mucous surface, he should see to it that the patient's general condition is good. Thorough asepsis is impossible, and a good result depends largely upon the vital resistance of the tissues. Before operating, irrigate the part frequently with boric acid, peroxid of hydrogen, or normal salt solution. When ready to sew up the wound be sure that all irritant fluids are removed (saliva in the mouth, etc.). Cleanse the wound with hot normal salt solution. The stitches must include submucous tissue as well as the mucous membrane, and consist of silver wire, silk, chromic catgut, or silkworm-gut. After sewing up a wound in the mouth, wash the cavity at frequent intervals with salt solution, and follow each washing with an insufflation of iodoform.

In accidental wounds irrigate with salt solution, dust with iodoform, and close as directed above. Corrosive sublimate is so irritant that it does harm when applied to a mucous membrane.

Contused and Lacerated Wounds.—A contused wound results from a blow or a squeeze which bruises and crushes the tissues and splits or ruptures the skin. It is a common injury when force is applied to tissues over a bone. The blow of a blackjack may cause either a contusion or a contused wound of the scalp. A contused wound is irregular in outline, with jagged edges, and

is surrounded by a broad zone of contusion. The worst form of contused wound is a crush of an extremity produced by being run over. The skin is often widely separated from the tissues beneath.

A lacerated wound results from tearing apart of the tissues. It too is irregular and jagged, and is accompanied by more or less contusion. A *brush-burn* is a contused-lacerated wound due to friction. Both lacerated and contused wounds contain masses of partly detached and damaged tissue, the vitality of which is endangered. Nerve-trunks, muscles, and great vessels may be torn across. Hence, such wounds are apt to slough, frequently suppurate, and are occasionally followed by cellulitis or even by gangrene. There is more danger of tetanus than in incised wounds. A wound especially apt to be followed by tetanus is made by the toy pistol. In contused and lacerated wounds the edges are discolored and cold to the touch, and there is little primary hemorrhage unless a cerebral sinus is opened or a great vessel is torn. There is considerable danger of secondary hemorrhage if large vessels have been bruised. In wounds of this nature the pain is often slight, but it may be violent. Shock is very severe.

Avulsion of a limb is a dreadful form of lacerated wound. The thumb or a finger may be torn off or the arm may be wrenched from the body with or without the scapula. In such cases the wound is large, jagged, and irregular, long strings of muscle or tendon hang from the gap, the wound edges are cold, but the bleeding is trivial. The shock is, of course, profound.

Avulsion of the scalp may be produced when the hair is caught in machinery. The American Indian inflicts this injury when he scalps a conquered foe. In some cases of avulsion of the scalp the periosteum is removed with the flap; in most it is not. The flap usually consists of skin and aponeurosis. In this form of laceration there is severe bleeding.

Treatment.—The surgeon brings about reaction and endeavors to asepticize the wound and skin about it (page 245), arrests hemorrhage, and ligates any visible damaged vessel whether it bleeds or not. Hopelessly damaged tissue should be cut away, doubtful tissue being retained. In some cases amputation is necessary. Secure thorough drainage, in some situations making counter-openings if necessary. Tube-drainage may be necessary or iodoform gauze in strands may be used. Contused wounds and lacerated wounds, except when on the face, are seldom closed by sutures. They are rarely closed because the damage is so great and the blood-supply so interfered with that primary union will not occur. In the face the blood-supply is so good that primary union may be obtained in part or entirely, and it is worth while to try to obtain it. Cold must not be applied to a region of lowered vitality, because it might cause gangrene. Heat is useful. Hence, it is advisable, even from the start, to dress with hot antiseptic fomentations, and this mode of dressing becomes imperative if sloughing begins. Of course the part must be kept at rest.

If suppuration occurs, the surgeon sees to it that the pus has free exit, and if necessary secures free exit by making incisions.

After avulsion of a limb the patient is reacted from shock, large vessels are sought for and tied, damaged tissue is cut away, the wound is packed with gauze and is *partly* approximated by sutures. After avulsion of the scalp bleeding vessels are carefully ligated. A portion of the scalp may be torn away, but a pedicle may connect it with the balance of this structure. In such

a case cleanse the parts thoroughly and suture the flap in place (W. T. Bivings, "Phila. Med. Jour.," June 7, 1902). If the portion of scalp is entirely separated, adopt Gussenbauer's suggestion when possible and graft pieces of the avulsed scalp. In any case the ulcer resulting from avulsion must be repeatedly grafted. Abbe in a case obtained healing after four years by the use of 12,000 grafts.

Punctured Wounds.—Punctured wounds are made wth pointed instruments, as needles, splinters, etc. The depth of a punctured wound greatly exceeds its surface area. After the withdrawal of the instrument inflicting the injury the wound partly closes at points, blood and wound-fluid cannot find exit, and if, as is probably the case, bacteria were deposited in the tissues, infection with pus organisms is very likely to occur, and if it does occur suppuration spreads widely. There is also danger of infection with tetanus bacilli. Such a wound may involve an important blood-vessel, and in such a case profuse hemorrhage may occur; otherwise hemorrhage is slight. A great cavity of the body may be penetrated or an important organ may be wounded. Large-sized foreign bodies may be driven into the tissues or a portion of the instrument may break off and lodge. Pain is rarely severe unless a considerable nerve has been damaged. If both a large vein and artery are punctured, varicose aneurysm or aneurysmal varix may arise.

Treatment.—When possible, inspect the instrument which did the damage to see if a piece has been broken off. If there is severe hemorrhage, enlarge the wound and tie the bleeding vessels. In a puncture not made by the surgeon, the wound must be regarded as infected. If a wound is made by a dirty instrument through skin known to be unclean, it is proper that the skin about the puncture be sterilized, that the wound be enlarged, that foreign bodies be removed, that the wound be irrigated with an antiseptic solution, or be painted with pure carbolic acid, and be drained with a tube or a strip of gauze. Such treatment, though painful, and appearing unnecessarily severe or even cruel to the sufferer from a trivial puncture, is necessary, and may save the patient from serious illness or from death. Every deep puncture inflicted by an instrument not surgically clean, and every puncture inflicted by a nail, a splinter, a meat hook, a rusty pin, a tooth of a cat or dog, etc., must be regarded as grossly infected and must be treated by incision, sterilization, drainage, hot antiseptic fomentations, and rest. If the puncture is superficial and is made with a smooth pointed instrument like a needle, when the instrument was not grossly infected the parts may be dressed with hot antiseptic fomentations, but they should be inspected daily for evidence of infection and at the first sign of trouble an incision must be made. If a foreign body is retained in the tissue, it must be removed.

Pure carbolic acid is a most efficient agent to sterilize a punctured wound.

If an important cavity of the body has been invaded by a puncture, exploratory incision is necessary (see Brain, Thorax, Abdomen).

Stab-wounds.—Stab-wounds were formerly considered with punctured wounds, but Senn wisely places them in a class by themselves ("Practical Surgery"). Stab-wounds are inflicted by penetrating the tissues with a pointed or narrow instrument—for instance, a dagger, a knife, the blades of scissors, a bayonet, or a sword. Such wounds are narrow and very deep. A stab-wound may cause rapid death by penetration of a large blood-

vessel. Some great cavity of the body may be penetrated and internal hemorrhage will then occur. The body may be transfixed by a sword or bayonet. Bone is rarely injured unless the skull is perforated or the chest entered. In stab-wounds there is usually great hemorrhage and shock.

Treatment.—Whenever possible, look at the instrument which did the damage and see if a piece is broken off. If no great cavity is entered, treat by general rules: arrest bleeding, react from shock, etc. The treatment of penetrating wounds of the abdomen, thorax, and cranium is discussed in the special sections.

Gunshot-wounds.—Gunshot-wounds are contused or contused-lacerated wounds inflicted by materials projected by explosives. A bit of rock or a crowbar hurled by dynamite inflicts a gunshot-wound, as does a shell-fragment, a pistol-ball, small birdshot, a rifle-bullet, a flying cap, a piece of wadding, grains of powder, a buckshot, a fragment of metal broken off a shell, grapeshot and canister, or a cannon-ball. Injuries by shell-fragments, portions of a bursted boiler, pieces of masonry or wood, are either lacerated or punctured wounds, and need no special consideration here. In this article we treat of injuries caused by bullets and shot.

The round bullet of the old-time musket being large, moving with comparative slowness, and flattening easily, is very apt to lodge. When it is fired from close range and strikes the tissue at a right angle it produces a "punched-out" entrance wound. If the velocity is low or the impact is not at a right angle to the tissues, the entrance wound may "be formed of triangular flaps," the corners of which are inverted.* The entrance wound is surrounded by a bruised area. The track of the bullet is larger than the bullet, is so badly contused and lacerated that much tissue is devitalized, and the shaft of a bone is apt to be splintered if struck. If the ball emerges, the wound of exit is larger than the bullet and forms triangular and everted flaps (Stevenson). Healing by first intention will rarely occur.

The conical or cylindrico-conoidal rifle-bullet has much greater velocity and penetrating power than the round bullet, hence it is more apt to perforate. The track of this bullet is less devitalized than is the track of the round ball and the surface is not so much contused. The wound of entrance is smaller than the bullet and is punched out or inverted. The wound of exit is larger than that of entrance, and is often everted. The bones are more seriously comminuted than by the round ball, and the fragments may be driven widely into the tissues (Stevenson); in fact, an explosive effect may occur at close range. Delorme lays it down as a rule that comminution of bone makes the wound of exit larger, and he asserts that a wound of exit larger in diameter than the thumb means that there is comminution of bone.

At the present day the old round ball is very rarely used, the conical projectile having taken its place. For the firearms of civilians, as a rule, the bullets are made of lead, hardened and shaped by compression, or hardened by an admixture with tin. The conical shape of the pistol-ball, the great velocity with which it is propelled and with which it rotates, and its hardness make it unlikely that at near range the bullet will only contuse and not enter the skin. It will almost always enter; it will often lodge and will not unusually perforate; it is rarely deflected, and is not nearly so much flattened by

* "Wounds in War," by Surg.-Colonel W. F. Stevenson.

impact as is the softer round ball. A pistol-ball or a spent rifle-ball, however, may fail to enter the tissues, grazing the surface and inflicting a brush-burn, or simply contusing the part. A bullet may enter the tissues, a cavity, or an organ, and lodge there, causing a penetrating wound. It may enter and emerge, causing a perforating wound. The bullet may not enter alone, but may carry with it bits of clothing or other foreign bodies. This complication is much more rare in injury by the conical bullet than by the round ball.

The military surgeon deals with wounds inflicted by small, densely hard, conical projectiles, which are impelled at a great velocity and are carried to long distances. A rifle whose caliber is less than 0.35 inch is known as a small-caliber rifle. The best known modern rifles are the Lee-Metford, Krag-Jorgensen, Mauser, Männlicher, Lebel, and Schmidt-Rubin.

Fig. 103.—Mauser bullet-wound of chest: *a*, Wound of entrance; *b*, point where bullet was extracted (Major Charles F. Kieffer, U. S. A.).

The old Springfield rifle, of a caliber of 0.45 inch, projected a bullet with a velocity of thirteen hundred feet in a second.

The Männlicher rifle, of a caliber of 0.25 to 0.32 inch, sends a bullet with a velocity of over two thousand feet a second. This bullet revolves with great velocity upon its own axis (two thousand times the first second) and is effective at several miles.

The bullet of the modern rifle (Fig. 104) is conical, has a leaden core, and is hardened by being covered with a mantle or jacket of copper, steel, nickel, or of alloys of copper and nickel, or of copper, nickel, and zinc. The hard jacket is absolutely essential, as the speed of the projectile is so great that no soft bullet could take the rifling, fragments would be torn from it in the gun, and the grooves of the barrel wound soon fill up with metal, the gun becoming useless.

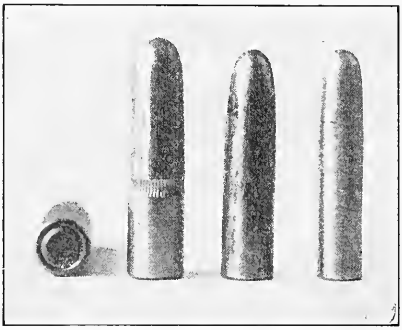
The Lee-Metford bullet is elongated in outline, has a core of lead hardened with antimony, and the envelope is composed of an alloy of nickel and copper.

The older projectile was apt to lodge; was often deflected in the tissues; was flattened out on meeting with resistant structures, such as bone or cartilage (Fig. 105), and after flattening became larger and tore and lacerated the soft parts and comminuted the bone.

The new projectile is apt to perforate, is rarely deflected, and is so hard that its shape is generally but little altered on meeting with resistant structures, and hence it was thought that the new bullet would prove more humane than the old projectile, and inflict wounds which would be more easily treated, because the bullets would not lodge and because extensive damage would not be inflicted. This view has proved to a great extent correct. In many instances a modern bullet will make a clear track without laceration or comminution. Senn, Nancrede, and other American surgeons in the Spanish-

American War say the modern projectile is humane at a range over fifteen hundred yards, as it generally penetrates cleanly, making a wound which heals by first intention. Sir Frederick Treves says "the Mauser bullet is a very merciful one." In some instances, however, the small bullet pulpefies structure for a considerable distance around the track of the ball by what is known as the explosive effect. This term does not mean that the bullet has exploded, but that its sudden impact against tissues has by waves of force caused extensive and distant damage, and often horrible and irreparable injury. Explosive effects are seen most often at close range, when the velocity of the ball and the frequency of its rotation are most marked. A pistol-ball has no explosive action at all, and the old-time bullet possessed it only at very close range. The modern projectile always produces explosive effects up to five hundred yards. Up to thirteen hundred yards it produces them upon the skull and brain. At this distance a single small projectile may entirely destroy the cranium and brain (see Demosthen's studies of the action of the Männlicher rifle). Explosive effects are noted at longer distances upon the liver, spleen, kidneys, and lungs, and upon hollow viscera containing fluid.

At a distance of five hundred yards or less a bone will be shattered into many fragments. At a range of fifteen hundred or two thousand yards the bone will be cleanly perforated, usually without comminution. It is often extraordinary how little trouble follows a wound and how quickly healing occurs. This is due to the fact that the bullet is sterile when it reaches the tissue, and that foreign bodies are rarely carried in with it. In some observed cases there have been almost no symptoms after perforation of the lungs, in others after perforation of the abdomen or joints or skull. It is obvious that the humanity of the modern rifle is largely a matter of range. At a range of fifteen hundred yards or more it is a humane weapon.



1 2 3 4

Fig. 104.—1, End view of 2, the Krag-Jorgensen bullet; 3, Mauser bullet; 4, Lee-Metford bullet, used by the United States Navy.

The wound of entrance is extremely small, and could be overlooked by a careless observer. It is usually circular, but may be triangular. The wound of exit is usually small, and may be round or may be a slit. If the injury was inflicted at close range, the wound of exit is large. This projectile theoretically does not flatten, but practically in many instances it does flatten a little, and in others its coat is torn off when it strikes hard bone at a distance of less than eighteen hundred yards (Fig. 106). Treves points out that if the bullet smashes a bone and lodges, the shell peels off from the core as a rule, and the bullet may be distorted or even broken into fragments. The bullet may lodge at long range, or if it hits a man after bounding from a stone. In Cuba 10 per cent. of the wounded suffered from lodged bullets. The old-style bullet rarely causes much primary hemorrhage, as the vessels as well as the nerves and tendons are usually pushed aside rather than cut. Hence secondary hem-

orrhage is common because of contusion of the vessel-walls. The modern bullet cuts rather than pushes aside the vessels. Hence primary hemorrhage is profuse if a large vessel is struck, and may prove fatal. The modern bullet rarely lodges and is rarely deflected. Skin is usually split by it. Fascia and muscle are usually much damaged, but in a transverse wound of muscle the fibers may be separated rather than destroyed (Conner). The effects of the modern bullet were determined by careful study and experiment; by an in-

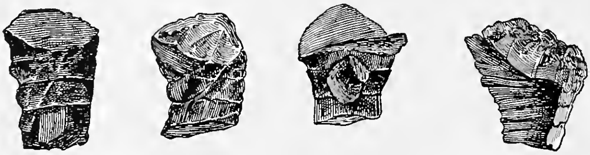


Fig. 105.—Deformation of leaden bullets (natural size) (Seydel).

Fig. 106.—Deformation of small-caliber jacketed bullets (after Bruns).

vestigation of the wounds in the Chitral Expedition and of wounds inflicted by accident or with homicidal or suicidal intent; by experiments: firing through boxes filled with wet sand; firing into thick oak; firing at cadavers at fixed distances with reduced charges (La Garde); firing at corpses and at live horses with service-charges (Demosthen). Nancrede cautions us to remember that experiments upon the cadaver, employing reduced charges and standing at fixed distances, are uncertain in their provings. "The difference between the velocity of rotation and angle of incidence with reduced charges at fixed distances and service-charges at actual distances is marked. The tension of living muscles and fasciæ, as compared with dead tissues, and the physical change of the semi-liquid fat of adipose tissue and medulla to a more solid condition by the loss of animal heat, influence the results." *

All theoretical conclusions have been put to the test in the Spanish-Amer-

* Nancrede upon "Gunshot-wounds," in Park's "Surgery by American Authors." For information upon wounds by the modern firearm, see recent reports of Surgeon-General of the United States Army; Demosthen's study of the wounds inflicted by the Männlicher rifle; Professor Conner, in Dennis's "System of Surgery;" Forwood, in "The International Text-Book of Surgery;" the elder Senn on "Medico-Surgical Aspects of the Spanish-American War;" Sir Frederick Treves, in the Lancet, May 12, 1900; Discussion in the British Medical Association, 1899; reports of Mr. G. H. Makins and Clinton T. Dent; Francis G. Abbott on the "Surgery of the Græco-Turkish War," in Lancet, Jan. 14, 1899; editorial in Boston Med. and Surg. Jour., May 4 and May 9, 1899; a study of "Gunshot Injuries by the Rifles of Reduced Caliber," by Louis A. La Garde, in Boston Med. and Surg. Jour., Nov. 1, 1900; J. Lynn Thomas, in Lancet, Nov. 3, 1900, and reports in various journals on wounds in the Russo-Japanese War.

ican War, the South African War, the taking of Pekin, and the Russo-Japanese War, and preconceived opinions have to a great extent been confirmed. The effect of the bullet at close range was observed in the marines killed at Guantanamo, in persons killed during the Milan riots, and in many instances in South Africa, China, and Port Arthur.

It has been found that the modern small-caliber bullet, unless it strikes a vital part or a large bone, lacks "stopping power," and in warfare with savages the bullet must have stopping power, or the wounded man will continue to fight and charge. Civilized men will usually stop when hit, savages often will not; hence, in warfare with barbarous people the ordinary bullet must be modified. In the Dumdum bullet a portion of lead at the apex of the projectile is left uncovered, and the bullet when it strikes spreads out—"mushrooms," as it is called—and inflicts an extensive wound which "stops" the most ferocious and fanatical. German surgeons denounce such bullets as inhumane, but Stevenson and other English surgeons say that the Dumdum bullet is more humane than the Snider or Martini-Henry. The name Dumdum comes from the ordnance factory, near Calcutta, where bullets of this character were first made.

Wounds by Cannon-balls.—A cannon-ball weighing five or six pounds may be imbedded in tissues. A ball or shell-fragments may tear off a limb or lacerate it extensively. In some cases of injury by spent balls the bone is destroyed and the muscles disorganized while the skin is intact.

Wounds by Small Shot.—The degree of injury is in direct ratio to the nearness of the individual to the gun when the discharge took place, to the size and number of the shot, and to the charge of powder. Single shot may bruise the surface or may enter the tissues. When many shot enter together they strike as a solid body. Single shot are usually deflected from vessels and nerves, and rarely lodge in bone, but rather flatten on its surface. Numerous shot entering together at close range produce extensive burns and fearful lacerations and inflict damage which is often irreparable. Pieces of clothing or other foreign bodies may be carried into the wound with the shot.

Blank Cartridge Injuries.—These injuries only occur at close range. They consist of burns and lacerations and frequently a wad is lodged in the tissues. Tetanus is liable to follow these injuries.

Symptoms of a Gunshot-wound.—Hemorrhage is often considerable, but ceases spontaneously unless a large vessel has been divided. If hemorrhage is profuse, the constitutional symptoms of hemorrhage exist. These symptoms are of great importance in abdominal wounds. A pistol-ball rarely causes severe primary hemorrhage, because it will not often penetrate a large artery. It is apt to push aside a vessel, and secondary hemorrhage is not unusual. Even if a large vessel is wounded and a succession of violent hemorrhages occur, a man may live for several days. Secondary hemorrhage may follow a gunshot-wound because of contusion of vessels or of infection.

Pain is often not noticed at first, especially if the injured individual was greatly pre-occupied or excited. There may be a feeling of numbness, but there is usually a dull or stinging pain. If a large nerve is injured, there may be violent pain. Even trivial gunshot-wounds frequently produce profound shock, and yet it may happen that severe wounds may be accompanied by

but slight shock. In most gunshot-wounds of the brain, abdomen, and spinal cord the shock is very great.*

General Considerations as to Treatment.—The dangers are shock, hemorrhage, and infection. Bullets are aseptic when they enter a part, and if infection is not inserted in the track of the ball the wound will in most instances heal kindly. "The fate of a wounded man is in the hands of the surgeon who first attends him" (Nussbaum). The danger of a wound depends upon the size and velocity of the bullet, the part struck, "and the degree of asepsis observed during the first examination and dressing" (Nancrede). The rules of treatment are: bring about reaction, arrest hemorrhage, preserve asepsis, and, in some cases, remove the ball. Always notice if a wound of exit exists. It is a good plan, when endeavoring to determine the extent

Fig. 107.—Nélaton's bullet probe.

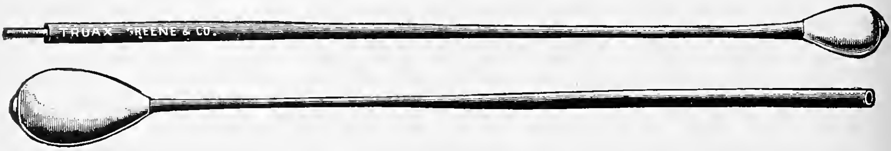


Fig. 108.—Senn's bullet probe.

Fig. 109.—Fluhrer's aluminum gravitation probe (natural size, except the length, which is twelve inches).

of injury, to put the parts in the position they were in when the injury was inflicted. We should try to ascertain the size and nature of the weapon, and the range at which it was fired. Examine the clothing to see if any fragments are missing and could have been carried in. Such fragments render sepsis almost inevitable. The surgeon must not feel it his duty to probe in all cases. In many cases it is better not to probe at all. Explore for the ball when sure that it has carried with it foreign bodies; when its presence at the point of lodgment interferes with repair; when it is in or near a vital region (as the brain); and when it is necessary to know the position of the bullet in order to determine the question of amputation or resection. If the wound is large enough, the finger is the best probe.

Fluhrer's aluminum probe is a valuable instrument (Fig. 109). It is employed especially in brain-wounds, and is allowed to sink into the track of the ball by the influence of gravity after the part has been placed in a proper position. If a lead bullet is deeply imbedded, it is possible to distinguish the hard projectile from a bone by inserting the asepticized stem of a clay pipe, a bit of pine wood, or *Nélaton's porcelain-headed probe* (Fig. 107). On any

* If the skin about some part of the wound is scorched and if powder grains are imbedded in it the weapon was fired at close range, probably within three feet. If the skin is not scorched and powder grains are not imbedded, we are not justified in contending that the bullet was not fired at a very near range. For the medico-legal questions determined by blackening, burning, and tattooing of the wound edges, consult a work on Legal Medicine.

one of these appliances lead will make a black mark. No such test can be applied to a modern bullet, for this has a hard metal jacket, and will not make a black mark on a white substance.

Though Nélaton's probe will not show the difference between a hard projectile and bone, it is a valuable instrument to follow the track of a wound. The porcelain head ought to be larger than it is usually made—in fact, it should be nearly the size of the bullet (Senn) (Fig. 108).

In passing a probe use no more force than in passing a catheter (Senn).

The *induction balance* of Graham Bell has been employed to determine the situation of a bullet. The bullet may be located by *Girdner's telephonic probe.* In order to construct this instrument, take a telephone receiver, fasten one of the wires to a metal plate and the other one to a metallic probe. Moisten a portion of the patient's body and place the metal plate in contact with it. The surgeon places the receiver to his ear and inserts the probe into the wound. If the probe strikes metal, a click is heard with distinctness. A bullet may be located by *Lilienthal's probe.* This apparatus consists of a mouth-piece, two insulated copper wires, and a probe. The mouth-piece is composed of two plates, one of copper and one of zinc, which are applied to the sides of the tongue. An insulated wire runs from each plate and into the metal probe. The tip of the probe is composed of two or four pieces of metal, is separated from the shank by a washer of rubber, and is attached to the wires. The

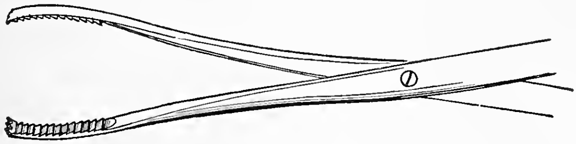


Fig. 110.—Bullet-forceps.

operator closes the teeth upon the mouth-piece, and inserts the probe into the wound. If the probe touches the bullet, a distinct and continuous metallic taste is appreciable.

The best means of discovering a bullet is to use the *fluoroscope* or take a *skiagraph.* In order to locate it accurately, view it through a series of squares, insert guide-pins, or, better than either of these plans, employ Sweet's apparatus. Bullets are readily seen by the fluoroscope in the superficial soft parts, and are discovered in deeper structures (bone, abdomen, lung, brain, etc.) by taking skiagraphs.

In extracting the ball use very strong forceps (Fig. 110). The old American bullet-forceps is useless for the extraction of the hard-jacketed ball, as the points will not penetrate and the instrument will not hold.

If hemorrhage is severe in a gunshot-wound, enlarge the wound, find the bleeding vessel, and tie it. Before handling a gunshot-wound asepticize the parts about it and irrigate the wound with hot sterile salt solution. In some situations a wound should be drained with a short tube or a bit of iodoform gauze; in other regions this is unnecessary. The dressing should be antiseptic. Primary union rarely takes place after a wound inflicted by a pistol-ball or an ordinary rifle-ball, because of the inevitable necrosis of damaged tissue in the track of the ball, but in some cases it can be obtained. Primary

union is frequent after injury by the small hard-jacketed modern projectile. Healing begins in the depths of the wound and extends toward the wound of entrance, or, if there be also a wound of exit, toward both. Radical operations may be demanded: laparotomy, trephining, rib-resection, joint-resection, or amputation.

Amputation is sometimes demanded because of great injury to the soft parts (as by a shell-fragment), the splintering of a bone, injury of a joint, damage to the chief vessels or nerves, or the destruction of a considerable part of a limb. Perform a primary amputation if possible, and make the flaps through tissue that will not slough. In civil practice, with careful antisepsis, more questionable tissue can be admitted into a flap than in military practice, where transportation will become necessary and antisepsis may be imperfect or wanting. It has been shown in recent years that even when a large joint has been perforated by a small hard-jacketed projectile, amputation or resection is rarely required if the wound was treated aseptically from the beginning.

Prevention of infection in wounds inflicted in war is of great importance. In warfare at the present day an attempt is made to limit the death-rate from gunshot-wounds by protecting them from infection at an early period after

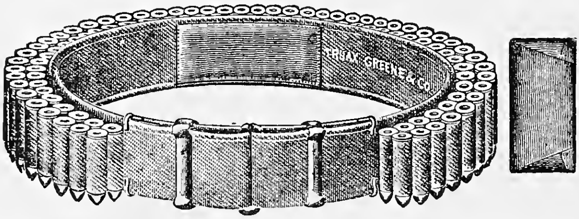


Fig. 111.—Cartridge belt with first-aid package sewed on inner surface.

the accident. Esmarch offered a suggestion, which has been adopted in the armies of all civilized countries. Every soldier carries a package which contains antiseptic dressings, and at the first opportunity after the infliction of a wound, if possible on the field, these dressings are applied by the soldier or by a comrade (for even the privates are instructed in the application), or by an ambulance man. If not applied on the field, they are applied at the first dressing-station by a surgeon or a hospital steward. Senn considers Esmarch's package too cumbrous.* He suggests a package containing half an ounce of compressed salicylated cotton. In the center of this cotton is an antiseptic powder (2 gm. of boric acid and 0.5 gm. of salicylic acid). The cotton is wrapped in a triangular gauze bandage. A safety-pin is placed in the bandage and the entire bundle is wrapped in gutta-percha tissue (Fig. 111). Senn says the triangular bandage is sufficient to hold a dressing in place, and it can be assisted by utilizing the gunstrap, safety-belt, or articles of clothing.† (For gunshot-wounds of special structures, see Bones, Joints, Abdomen, Brain, etc.) When a wound has been inflicted by a *blank cartridge*, the surface should be cleansed, the wound irrigated, foreign bodies removed, the parts sterilized, and

* Jour. Am. Med. Assoc., July 13, 1895.
† Senn, in Jour. Am. Med. Assoc., July 13, 1895.

dressed with hot antiseptic fomentations. In some cases the wound should be enlarged; in some, powder grains should be removed from the skin. In view of the danger of lockjaw and because tetanus bacilli do not multiply when exposed to oxygen, some surgeons advocate keeping such wounds exposed to the air throughout the treatment. After an injury with *shot*, bleeding should be arrested, the parts should be cleansed, bits of clothing and other such foreign bodies should be removed, and antiseptic dressings should be applied. It is not necessary to remove the shot unless they are doing harm or unless they lie just beneath the skin.

Poisoned wounds are those into which some injurious substance, chemical or bacterial, was introduced. This poison may be microbic and capable of self-multiplication, or it may be chemical, and hence incapable of multiplication. There are three classes of poisons: * (1) mixed infection, as septic wounds, dissection-wounds, and malignant edema; (2) chemical poison, such as snake-bites and insect-stings; and (3) infection with such diseases as rabies, glanders, etc.

Septic wounds are those which putrefy, suppurate, or slough. Septic wounds should be opened freely to secure drainage, and hopelessly damaged tissue should be curetted or cut away. The wound should be washed with peroxid of hydrogen and then with corrosive sublimate, dusted with iodoform or orthoform, either drained with a tube or packed with iodoform gauze, and dressed with hot antiseptic fomentations. The part must be kept at rest and internal treatment should be stimulating and supporting. If lymphangitis arises, the skin over the inflamed vessels and glands is to be painted with iodin and smeared with ichthyol, and quinin, iron, and whiskey are given internally. The temperature is watched for evidence of general infection or intoxication. The patient must be stimulated freely, nourishing food is given at frequent intervals, pain is allayed by anodynes if necessary, and sleep is secured.

Dissection-wounds are simple examples of infected wounds, and they present nothing peculiar except virulence. They affect butchers, cooks, surgeons who cut themselves while operating on infected areas, those who make post-mortems, and those who dissect. A dissection-wound inflicted while working on a body injected with chlorid of zinc possesses but few elements of danger unless the health of the student is much broken down. If a wound is simply poisoned with putrefactive organisms, there is rarely serious trouble. Post-mortems are peculiarly dangerous when the subject has died of some septic process. When a wound is inflicted while dissecting, wash it under a strong stream of water, squeeze, and suck it to make the blood run, lay it open if it be a puncture, paint it with pure carbolic acid, and dress it with iodoform and hot antiseptic fomentations. Trouble, of course, may follow, but often it is only local, and a small abscess forms. It should be treated by hot antiseptic fomentations and early incision. Occasionally lymphangitis arises, adjacent glands inflame, and constitutional symptoms arise. It is rarely that true septicemia or pyemia arises unless the wound was inflicted while making a post-mortem upon a person dead of septicemia or while operating on a septic focus. If glands enlarge and soften, it may be necessary to remove them surgically.

Malignant edema or **gangrenous emphysema** arises most commonly

* "American Text-Book of Surgery."

after a puncture. It is due to a specific bacillus which produces great edema. The emphysema which soon arises is due to mixed infection with putrefactive organisms. Pus does not form, but gangrene occurs. The disease is identical with one form of traumatic spreading gangrene (page 174).

Symptoms.—The symptoms are identical with those of traumatic spreading gangrene with emphysema.

There is a rapidly spreading edema, followed by gaseous distention of the tissues and by gangrenous cellulitis. The zone of edema is at the margin of the emphysema, and the process spreads rapidly. The emphysematous zone crackles when pressed upon. The area of edema is covered with blebs which contain thin, putrid, reddish matter, and the skin becomes mottled. If a wound exists, the discharge will be bloody and foul. If incisions are made, a thin, brown, offensive liquid flows out. High fever rapidly develops, the patient becomes delirious, and often coma arises. In most cases death ensues in from twenty-four to forty-eight hours.

Treatment.—If malignant edema affects a limb after a severe injury amputate at once, high up. If it affects some other part or begins in a limb after a trivial injury, make free incisions, employ hot, continuous antiseptic irrigations or the hot antiseptic bath, and stimulate freely (page 175).

Stings and Bites of Insects and Reptiles: Stings of Bees and Wasps.—A bee's sting consists of two long lances within a sheath with which a poison-bag is connected. The wound is made first by the sheath, the poison then passes in, and the two barbed or twisted lances, moving up and down, deepen the cut. The barbs on the lances make it difficult to rapidly withdraw the sting, which may be broken off and remain in the flesh. Besides bees, hornets, yellow jackets, and other wasps produce painful stings. The sting of a wasp is rarely broken off in the tissues because the beards on the darts are shorter and hence the sting is not so firmly fixed in the flesh, and also because these insects are more rapid and nimble in their actions. Stings of bees and wasps rarely cause any trouble except pain and swelling. In some unusual cases a bee-sting is fatal; persons have been stung to death by a great number of these insects.

Symptoms.—If general symptoms ensue, they appear rapidly, and consist of great prostration, vomiting, purging, and delirium or unconsciousness. These symptoms may disappear in a short time, or they may end in death from heart-failure. Stings of the mouth may cause edema of the glottis.

Treatment.—To treat a bee-sting, extract the sting with splinter forceps if it has been broken off and is visible in the wound. If it is not visible, squeeze the part lightly in order to expel it, or at least expel the poison. Pressure may be most satisfactorily made by means of the barrel of a key. The poison is counteracted by touching with ammonia or washing the part in ammonia-water, touching with pure carbolic acid, painting with tincture of iodin, or soaking in a strong solution of common salt or carbonate of sodium. The part may be dressed with lead-water and laudanum, a solution of washing-soda, or a solution of common salt. If constitutional symptoms appear, stimulate.

Other Insect-bites and Stings.—The mandibles of a *poisonous spider* are terminated by a movable hook which has an opening for the emission of poison. The bite of large spiders is productive of inflammation, swelling,

weakness, and even death. The bite of the poisonous spider of New Zealand produces a large white swelling and great prostration; death may ensue, or the victim may remain in a depressed, enfeebled state for weeks or even for months. The *tarantula* is a much-dreaded spider. The scorpion has in its tail a sting. The sting of the *scorpion* produces great prostration, delirium, vomiting, diaphoresis, vertigo, headache, local swelling, and burning pain, followed often by fever and suppuration, and occasionally even by gangrene, but it is rarely fatal. *Centipedes* must be of large size to be formidable to man, and the symptoms arising from their stings are usually only local.

Treatment.—Tie a fillet above the bitten point; make a crucial incision, favor bleeding, and paint the wound with pure carbolic acid or some caustic or antiseptic (if in the wilds, burn with fire or gunpowder); dress antiseptically if possible, and stimulate as constitutional symptoms appear. Slowly loosen the ligature after symptoms disappear. Chloroform stupes and ipecac poultices are recommended; also puncture with a needle and rubbing in a mixture of 3 parts of alcohol and 1 part of camphor (Bauerjie).

Snake-bites.—The poisonous snakes of America comprise the copperheads, water-moccasins, rattlesnakes, and vipers. The cobra of India is a deadly reptile. In some countries great numbers of people and the lower animals are killed by poisonous serpents. In India during 1898, 21,921 persons and at least 80,000 cattle were killed by snakes ("Brit. Med. Jour.," Nov. 25, 1899). It used to be taught that there is no essential difference in the action of venoms of different varieties of snakes and that the venom of an Indian cobra is practically identical with the venom of an American rattler, any apparent difference in action depending upon difference in toxic power and the different dose of poison introduced. We now know that there are essential differences in venoms (Leonard Rogers, in "Lancet," Feb. 6, 1904). The natural toxic power of the poison varies in different species and also in different members of the same species. Poison injected into a vein may prove almost instantly fatal. The poison is not absorbed by the sound mucous membranes. Poison is harmless when given by the mouth and swallowed, but if directly introduced into the intestine of an animal it is certainly fatal. The pancreatic ferment destroys the toxic power of the venom (R. H. Elliot, in "Brit. Med. Jour.," May 12, 1900). The venom is discharged through the hollow fangs of the reptile, having been forced out by contractions of the muscles of the poison-bag. In most varieties of snakes the teeth lie along the back of the mouth and are only erected when the reptile strikes. Snake-poison is a thin, greenish-yellow, turbid, sterile fluid, of acid reaction and of a distinctive odor. The two chief poisonous principles are called venom-peptone and venom-globulin (Gustave Langmann, "Medical Record," Sept. 15, 1900).

Symptoms.—Rogers ("Lancet," Feb. 6, 1904) divides poisonous snakes into two classes: the *colubrines* (of which the cobra is an example) and the *viperines*, which are not so poisonous (this class includes rattlesnakes and puff adders). Colubrine venom, according to this observer, causes paralysis of the respiratory center and of the motor end organs of the phrenic nerves, destruction of red blood-corpuscles, lessened coagulability of blood, and death by respiratory paralysis. Viperine venom causes paralysis of the vaso-motor center, great destruction of red corpuscles, some viperine venoms may cause

thrombosis, and death from any one of them is due to vaso-motor paralysis. The venom of some snakes, Rogers says, contains a mixture of the above-mentioned venoms (among such snakes are the Australian colubrines and the American pit adders). The mortality from snake-bites varies. The mortality in India from cobra bites is about 25 per cent. (Sir Joseph Fayrer). The mortality in America from rattlesnake bites is about the same. The local symptoms are: pain, soon becoming intense; mottled swelling of the bitten part, which swelling may be enormous, and which is due to edema and extravasation of blood, and assumes a purpuric discoloration. The *bite of a cobra* produces inflammation and marked spreading edema. It may be recovered from without symptoms or with trivial symptoms it may induce profound systemic involvement. The general symptoms begin in a comparatively few minutes. The coagulating power of the blood is lost, there is great destruction of red corpuscles. The patient is terror-stricken and soon becomes unable to stand because of weakness of the legs. Glosso-laryngeal paralysis arises, and talking and swallowing become impossible. There is a profuse flow of saliva, perhaps nausea and vomiting. The patient may be dull mentally but is not unconscious. The paralysis becomes widespread, and finally the diaphragm and respiratory center become involved, and death occurs from respiratory paralysis. Artificial respiration may prolong life for hours (Sir Joseph Fayrer). Bad cases usually die in three or four hours, but life may last for many hours. A *rattlesnake* bite produces severe pain and mottled swelling from blood extravasation. In some cases there is enormous swelling from edema and blood; the discoloration in such a case is purpuric. The blood of the victim quickly undergoes hemolysis and loses the power of coagulation. It was previously stated that in laboratory experiments it has been shown that viperine poison may produce thrombosis, but it does not do so in man, as it contains a very small amount of the coagulating element (Rogers). Extravasations of blood occur in serous and mucous membranes and in the skin, petechial spots frequently arising upon the cutaneous surface. There may be free bleeding from mucous surfaces and great extravasation beneath the conjunctivæ. These blood extravasations are due, according to Flexner, to destruction of vascular endothelium. General symptoms begin in from a few minutes to several hours. The symptoms are those of profound shock, possibly with delirium, the vaso-motor center being exhausted and finally paralyzed. There is usually muscular twitching, convulsions, and finally paralyses are noted in most cases (pharyngeal palsy, paraplegia, and ascending paralysis). There may be complete consciousness, or there may be lethargy, stupor, or coma. Death may occur in about five hours, but, as a rule, it is postponed for a number of hours. If death is deferred for a day or more, profound sepsis comes upon the scene, with glandular enlargement, suppuration, and sometimes gangrene.

Treatment.—Cases of snake-bite must, as a rule, be treated without proper appliances. The elder Gross was accustomed to relate in his lectures how he had seen an army officer blow off his finger with a pistol the moment after it was bitten by a rattlesnake, and thus escape poisoning. In general, the rules are to twist several fillets at different levels above the bite, to excise the bitten area, to suck or cup it if possible, and to cauterize it with pure acid or by heat. An expedient among hunters is to cauterize by pouring a very little

gunpowder on the excised area and applying a spark, or by laying a hot ember on the wound. When a hot iron is available, use it. The fillets are not to be removed suddenly, and they had best be kept on for some time. Remove the highest constricting band first; if no symptoms come on after a time, remove the next, and so on; if symptoms appear, reäpply the fillet. Some surgeons inject in many places about the wound a few drops of a 10 per cent. watery solution of chlorid of calcium. It is taught by others that if a man is bitten by a large and deadly snake, the surgeon, if one is at hand, should at once amputate well above the bite.* Wynter Blyth pointed out that permanganate of potassium mixed with an equal weight of cobra venom renders the venom inert. A number of surgeons have treated snake bites by injecting in and about the wound a 1 per cent. solution of permanganate of potassium, but this plan is inefficient. Rogers ("Lancet," Feb. 6, 1904) says we should tie a fillet around the limb above the bitten part, take a knife and enlarge the wound and rub in crystals of permanganate. Whatever local treatment is employed stimulants are to be given and large doses of alcohol are very generally relied upon. Some give strychnin hypodermatically, others ether, others digitalis. Halford, of Australia, advocated the intravenous injection of ammonia (10 ♏ of strong ammonia in 20 ♏ of water). Adrenalin as given in shock, is indicated if the vaso-motor center is becoming paralyzed, and auto-transfusion and external heat are also indicated. If the respiration is failing artificial respiration and oxygen inhalation are required. Attempts are being made to obtain a curative serum. Animals can be rendered immune by giving them at first small doses of the poison and gradually increasing the amount administered. It is asserted that the serum of immune animals will cure a person bitten by a venomous snake. Cures have been reported after the use of Calmette's antivenene serum. The dose is from 10 c.c. to 20 c.c. hypodermatically, repeated if necessary in three or four hours. It seems certain, however, that no single serum can antidote the venom of all varieties of serpents (A. T. F. Macdonald, of Australia), and it has been shown that, though Calmette's antivenene is antagonistic to colubrine venom, it is inert against viperine venom (Rogers). Again, as Rogers says, it deteriorates quickly in hot climates and is seldom on hand when wanted.

The poisonous lizard (Gila monster) can kill small animals, but it is not believed that its bite would prove fatal to man.

Anthrax (Malignant Pustule, Charbon, Wool-sorters' Disease, Milzbrand, or Splenic Fever) is a term used by some as synonymous with ordinary carbuncle, but it is not here so employed. It is a specific contagious disease resulting from infection with the bacillus of anthrax. Animal anthrax is particularly common in the East and in Russia, and is frequently met with in Germany, Italy, and South America. In some regions so many cases arise year after year that the region obtains an evil notoriety. It is stated that in Novgorod, Russia, in four years, "56,000 horses, cattle, and sheep, and 528 men are reported to have perished from anthrax" (Frank S. Billings, in "Twentieth Century Practice"). It is a rare disease in the United States. In Philadelphia cases occasionally arise in workers in the woolen mills. The author has seen three cases of human anthrax, two of which arose in Philadelphia and one in New Jersey. Herbivora are most liable, next

* Charters James Symonds, in "Heath's Dictionary of Practical Surgery."

omnivora, but carnivora seldom suffer. Anthrax, as met with in man, is a disease contracted in some manner from an animal with splenic fever. It may be contracted by inoculation by working around diseased animals, by handling or tanning their hides or by sorting their hair or wool; brush-makers, spinners, workers in horn, and combers, rag sorters, veterinary surgeons, clippers, stockmen, farmers, and butchers may become inoculated; it may be conveyed by eating infected meat or by drinking infected milk. Flies may carry the poison. Inhalation of poisoned dust may infect the lungs. Catgut ligatures may be contaminated and carry the poison. Many attempts, not altogether satisfactory, have been made to render animals immune (Pasteur, Woolbridge, Hankin). Certain organisms are antagonistic to anthrax (the streptococcus of erysipelas, the pneumococcus, the micrococcus prodigiosus, and the bacillus pyocyaneus).

Forms of Anthrax.—There are two forms of the disease—external and internal. Internal anthrax may be intestinal from eating diseased meat or pulmonary from inhalation of poisoned dust. Intestinal anthrax arises only when the bacilli in the meat contain spores. Koch and others have pointed out that the non-sporulating bacteria are destroyed by the gastric juice. **External anthrax** may be *anthrax carbuncle* or *anthrax edema*. *Anthrax carbuncle* or *malignant pustule* appears on an exposed portion of the body, especially the hand or fingers, in over 80 per cent. of cases of external anthrax. I saw one upon the temple. It appears in from twenty-four hours to six days after inoculation, and presents an itching, burning papule with a purple center and a red base; in a few hours the papule becomes a vesicle which contains bloody serum and the tissues about the papule become swollen, reddened, and indurated. The vesicle bursts and dries, the base of it swells and enlarges, other vesicles appear in circles around it, and there is developed an "anthrax carbuncle," which shows a black or purple elevation with a central depression surrounded by one or more rings of vesicles. The surrounding tissues become purple, and great edema may spread widely, the vesicles grow very large and new vesicles form, and gangrene may occur. Pain is trivial or absent. Lymphatic enlargements occur but pus does not form. Within forty-eight hours after the pustule begins micro-organisms usually appear in the blood. The constitutional symptoms may rapidly follow the local lesion, but may be deferred for a week or more. The patient feels depressed, has obscure aches and pains, and is feverish, but usually keeps about for a short period. After a time he is apt to develop rigors, high irregular fevers, sweats, acute fugitive pains, diarrhea, delirium, typhoid exhaustion, dyspnea, cough, and cyanosis. The carbuncle of anthrax is distinguished from ordinary carbuncle by the central depression, the adherent eschar, the absence of pain, tenderness, and suppuration of the first, as contrasted with the elevated center, the multiple foci of suppuration and sloughing, and the more severe pain usual in the second. If anthrax has a visible lesion and the constitutional symptoms are slight or absent the chance of cure is good. In cases which get well a line of demarcation forms about the pustule and the gangrenous area is rather rapidly cast off, a granulating surface remaining.

Anthrax Edema.—An area of edema surrounds a malignant pustule and often spreads widely, but in cases of external anthrax without a pustule there is edema alone. This lesion occurs in connective tissue, especially loose

tissue. It is a spreading, livid edema, with an ill-defined margin. There is no pain and usually no vesication and no fever. In severe cases, however, there is fever, vesicles form, and gangrene may arise. Anthrax edema differs from cellulitis in the absence of pus formation, and from malignant edema by the less disposition to result in gangrene. Two of the cases I have seen were anthrax edema. In Horwitz's case in the Philadelphia Hospital the forearm, arm, and shoulder were enormously edematous. In Keen's case in the Jefferson College Hospital the forearm and arm were edematous.

Prognosis.—The usual estimate of the death rate from external anthrax is from 25 to 30 per cent. If upon the face the prognosis is much worse than if upon the extremities, and if upon the upper extremity worse than if upon the lower. The death rate has been notably reduced by modern treatment and under serum treatment is said to be but little over 6 per cent.

Pulmonary anthrax and intestinal anthrax have been regarded as invariably fatal, but vastly better results may be looked for hereafter.

Treatment of External Anthrax.—If a person is wounded by an object suspected of carrying the infection, cauterize the wound with the hot iron. A sufferer from anthrax must be isolated in a well-ventilated room. All dressings are to be burned, all discharges asepticized, and after the removal of the patient the bed-clothes are burned and the room disinfected. A malignant pustule should be entirely excised, and the wound mopped out with pure carbolic acid or burned with the hot iron. If there is an extensive area of edema it should be freely incised at several points. The area about the excised pustule should be injected with a 5 per cent. solution of carbolic acid. The wound and the edematous area should be dressed with hot antiseptic fomentations, and, if dealing with an extremity, a splint is applied. Excision should be practiced even when glands are enlarged, but it will prove ineffectual, as a rule, if organisms are present in the blood. When excision cannot be performed make crucial incisions through the lesion, mop the wounds with pure carbolic acid, and inject about and in the pustule carbolic acid (1 : 20) every six hours until the disease abates or toxic symptoms appear. Dress the part as directed above. In a successful case the adherent eschar is finally separated by the influence of the fomentations. Davaine advised the following plan: Inject the pustule and the tissues about it at many points every eight or ten hours with 1 part of tincture of iodin diluted with 2 parts of water or with a 10 per cent. solution of carbolic acid, or with a 0.1 per cent. solution of corrosive sublimate. Dress with wet antiseptic gauze and apply an ice-bag. Personally I would not use an ice-bag on an area of infection but would prefer heat. In anthrax edema inject a 5 per cent. solution of carbolic acid into the apparently sound skin and subcutaneous tissue just above the margin of the edema and repeat the injections every six hours. Make free multiple incisions in the edematous area carrying each incision down to the deep fascia. Dress with hot antiseptic fomentations and if dealing with a limb apply a splint. In Keen's very severe case of anthrax edema, this treatment was carried out by George J. Schwartz and recovery followed. Constitutional treatment in anthrax edema or malignant pustule must be sustaining and stimulating. Maffucci gives carbolic acid internally, and also uses it externally. Davies-Colley uses ipecac locally and gives gr. v by the mouth every four hours. Statistics indicate

that the serum treatment is of the greatest value. The material is known as Sclavo's serum; it is obtained from the immunized ass, and it was introduced into practice in 1897. It is perfectly harmless and may be given in a vein or subcutaneously. Sclavo injects 40 c.c. in different regions of the wall of the abdomen. If improvement is not obvious in twenty-four hours the dose is repeated. Intravenous injection is reserved for severe cases, the dose being 10 c.c. into a subcutaneous vein of the dorsal surface of the hand. The persistence of anthrax infection in a room was well shown in the record of Keen's case. The infection lingered on the floor of the room in which the patient had been operated upon for a long time. Three disinfections were necessary before it became impossible to obtain anthrax bacilli from the contaminated floor. This indicates that such a case should be operated upon in a room not regularly used for operations.

Hydrophobia, Rabies or Lyssa.—Hydrophobia is a spasmodic and paralytic disease due to infection through a wound with the virus from a rabid animal. The disease does not appear to arise except as the result of inoculation. It is most common in dogs and wolves, but it may develop in cats, horses, goats, foxes, cattle, sheep, and pigs. It is far more common in the carnivora than the herbivora. It is said that poultry may suffer from it. Human hydrophobia in most instances follows dog bites. Roux estimates that about 14 per cent. of the people bitten by mad animals develop the disease. If the bite is on an exposed part, it is far more apt to cause rabies than if the rabid animal's teeth passed through clothing. The saliva is the usual vehicle of contagion, but other fluids and tissues contain the virus, especially the brain and cord. Hydrophobia has been known for centuries. It is not spoken of by Hippocrates, but is described by Aristotle, Pliny, and Celsus, and is alluded to by Plutarch. At the present day some ardent antivivisectionsts dispute its existence. The fact that an infant bitten by a rabid animal may develop rabies proves that the disease is not due to the imagination. Hydrophobia is almost invariably fatal. No causative bacterium has been demonstrated. One must exist but it probably escapes detection because of its very small size. The poison cannot gain entrance through sound mucous membrane. It used to be thought that the disease was particularly apt to arise in hot weather, but it is now known that it may occur any time of the year. No constant post-mortem lesions have been certainly demonstrated in those dead of rabies. Gowers believes that in the spinal cord there is hyperemia, but no infiltration with cells, whereas in the medulla, especially about the respiratory center, there are hypermia and cellular infiltration of the perivascular spaces. But such perivascular infiltration can occur in some other acute conditions and hence is not characteristic. What is known as the *rabic tubercle* is found in the medulla and about the motor cells of the upper part of the spinal cord. Each tubercle consists of an aggregation of cells. Babés thinks the tubercle characteristic. Infiltration of the ganglia with epithelioid cells and round cells has been held by some to be characteristic. But both the rabic tubercle and ganglion infiltration occur in other conditions. The disease is extremely rare in the United States, and the author has never seen a single case.

Symptoms.—The period of incubation of human hydrophobia is from a few weeks to several months, and it has been alleged that it may even be two

years, but it is very doubtful if there is ever a period of incubation of over six or seven months. The average incubation period in man is forty days (Ravenel). The initial symptoms are mental depression, anxiety, sleeplessness, restlessness, headache, malaise, and often pain or even congestion in the cicatrix. The anxiety which is usually present may be deepened into actual fear. In dogs the condition of fear is so evident that Cælius Aurelianus centuries ago called the disease *pantophobia* (fear of everything). The previously-mentioned symptoms are quickly followed by dysphagia. It is not only water that is difficult to swallow but everything the patient tries to drink or eat. The difficulty in swallowing results apparently from apnea produced instantly when an attempt is made to swallow. Curtis points out that the difficulty is not spasm of the pharynx and larynx, but is a sense of immediate suffocation due to reflex stimulation of respiratory inhibition. If spasms occur—and they may occur—they are secondary to this suffocative state, a state in which the action of the diaphragm ceases for a time. The air-passages become congested and the sufferer makes frequent and painful efforts to expel thick mucus, and the efforts produce paroxysms of suffocation. Between the paroxysms the patient is evidently somewhat breathless, and Warren tells us that his speech is not unlike that "of a child who has recently been crying and is endeavoring to control itself" ("Surgical Pathology and Therapeutics"). As the condition grows worse, suffocative attacks, which were at first induced by attempts at swallowing, come to be caused also by bright lights, sudden or loud noises, irritations of the skin, or even thinking of swallowing. At length suffocative paroxysms occur spontaneously and the patient jumps, or hurls himself about, or the muscles of the entire body are thrown into clonic spasm. Tonic spasm does not occur. A condition of general hyperesthesia exists. The mind is usually clear, although during the periods of excitement there may be maniacal furor with hallucinations which pass away in the stage of relaxation. The temperature is moderately elevated (101° to 103° F. or higher). The spasmodic stage lasts from one to three days, and the patient may die during this stage from exhaustion or from asphyxia. If he lives through this period, the convulsions gradually cease, the power of swallowing returns, and the patient succumbs to exhaustion in less than twenty-four hours, or he develops ascending paralysis which soon causes cardiac and respiratory failure. In what is known as *paralytic rabies*, a very rare form of the disease in human beings, the attack comes on with the same early symptoms met with in the commoner form, but paralysis soon begins about the bitten part and spreads to all the limbs and to the trunk.

In hydrophobia death is almost inevitable. Practically all cases in which it is alleged that recovery ensued were not true hydrophobia, but hysteria. An exception must be made of Murri's case. Wood says that in hysteria, especially among boys, "beast-mimicry" is common, the sufferer snarling like a dog; and in the form known as "*spurious hydrophobia*," in which there may or may not be convulsions, there are a dread of water, emotional excitement, snarling, and attempts to bite the bystanders (in genuine hydrophobia no attempts are made to bite, and no sounds are uttered like those made by a dog).

Lyssa is separated from lockjaw by the paroxysms of suffocation and the

absence of tonic spasms in the former, as contrasted with the fixation of the jaws and the tonic spasms with clonic exacerbations of lockjaw.

Treatment.—When a person is bitten by a supposed rabid animal and is seen soon after the injury, constriction should be applied if possible above the wound, the wounded area should be excised, cauterized with a hot iron or the Paquelin cautery, and dressed antiseptically. If the patient is not seen for a number of hours or a day or two after the injury, cauterization is useless; and it is not only useless, but it may delude the patient and his friends into a feeling of security. In any case, send the patient at once to a Pasteur institute. If the animal which inflicted the injury was not hydrophobic, no harm will result from inoculations; if it was hydrophobic, preventive treatment may save the patient. The method known as the preventive treatment was devised by Pasteur who discovered the following remarkable facts: If the virus of a rabid dog (street rabies) be placed beneath the dura of another dog, it *always* causes hydrophobia in from sixteen to twenty days, and invariably causes death. If the virus is passed through a series of rabbits it gets stronger (laboratory virus), and if inserted beneath the dura of a dog it causes the disease in from five to six days, and kills in four or five days. The virus can be attenuated by passing it through a series of monkeys or by keeping it for a definite time. To obtain attenuated preparations in a convenient form Pasteur made emulsions from the spinal cords of hydrophobic rabbits, the animals having been dead two or three weeks. He found that the emulsion obtained from the rabbit longest dead is the weakest. He injected a dog with emulsions of progressively increasing strength and made it immune to hydrophobia. The patient is injected with an emulsion made from the dried spinal cords of hydrophobic rabbits. In this emulsion the virus is attenuated, and day by day the strength of the injected virus is increased. These emulsions cause the body-cells to form antitoxin, and either the virus of street rabies does not develop at all or by the time it begins to develop a quantity of antitoxin is present to antagonize it. In the New York Pasteur Institute patients remain under treatment for fifteen days, two inoculations being given daily. In cases in which treatment is begun late, or in which the head or face was bitten, from four to six inoculations are given each day. The report of the Parisian Pasteur Institute shows that since its foundation there has been a mortality of 0.5 per cent. The lowest estimated number of those attacked by hydrophobia before this method was used was 5 per cent. of those bitten, and all attacked died; hence, the Pasteur treatment as applied in the Parisian Institute shows one-twenty-fifth of the mortality which attends other preventive methods. Ravenel, in 1901, estimated that 55,000 persons have been treated by the Pasteur method and that 1 per cent. have died. The value of this plan seems definitely established. The general public believe that the dog which did the biting should be killed. The dog should, if possible, be locked up and watched rather than killed. It may be proved in this way that it did not have hydrophobia. If it were necessary to kill the dog, or if the dog was killed at once or soon after, the physicians of the New York Pasteur Institute advise that the dog's head be cut from the body with an aseptic knife and a piece of the medulla oblongata be abstracted. The bit of medulla should be placed in a mixture of equal parts of glycerin and water which was previously sterilized by boiling. The bottle should be sealed and sent

to the Institute, in order that inoculations may be made upon animals to prove the existence or absence of hydrophobia. In the paroxysm of hydrophobia the treatment in the past was purely palliative. If we employ only palliative methods, keep the patient in a dark, quiet room, relieve thirst by enemata, saturate him with morphin, empty the bowels by enemata, attend to the bladder by regular catheterization, and during the paroxysms anesthetize. Murri, of Bologna, cured a case of hydrophobia by injecting emulsions of cords of rabbits dead six, five, four, and three days respectively. It would be proper to try this remedy if hydrophobia develops. A serum has been prepared by Tizzoni and Centani which they claim is successful in treating the disease as experimentally induced in the laboratory. The remarkable suggestion has come from Tizzoni, that rabies be treated with rays of radium, it having been shown that rabic virus can be destroyed by radium.

Glanders, Malleus, Farcy, or Equinia.—Glanders is an infectious eruptive fever occurring in horses, asses, and some other animals, and communicable to man. If the nodules occur in the nares, the disease is called "glanders"; if beneath the skin, it is termed "farcy." This disease is due to the bacillus mallei and is communicated to man through an abraded surface or a mucous membrane. The characteristic lesions are infective granulomata in the nares, skin, lungs, and subcutaneous tissue. In the nares granulomata result in ulcers and under the skin break down into abscesses. From the site of inoculation the bacilli are disseminated and the cutaneous and muscular structures and lungs become involved. The disease is most common in the horse but occurs also in the ass, mule, cat, rabbit, goat, and other animals. Man can be infected from a diseased animal and as the common source of infection is the horse the usual victims are those who use or work about horses. The period of incubation after infection is four or five days.

Acute and Chronic Glanders.—In acute glanders there is septic inflammation at the point of inoculation; nodules may form in the nose and ulcerate; there is profuse nasal discharge; the glands of the neck enlarge; there is weakness, frontal headache, chilliness, pain in the back and limbs; often diarrhea; after a time the muscles become painful; there is fever, the evening temperature being 100° or higher, and the morning temperature being lower. Chills may occur. There may be chest pains, severe muscular pain, bronchitis, and signs of pulmonary congestion. It may not be suspected that the patient has glanders and the diagnosis of typhoid may perhaps be made. Twelve to fourteen days after the beginning of the trouble little hard lumps arise in the muscles and just beneath the skin. In a few days the lumps soften, break down, and discharge a bloody fluid which contains the bacilli of glanders. In a number of cases an eruption resembling smallpox appears on the face and about the joints. It differs from smallpox in not being umbilicated. Leukocytosis exists. Mallein, a material corresponding to tuberculin, has been used for diagnostic purposes upon animals. Acute glanders is nearly always fatal. Chronic glanders lasts for months, is rarely diagnosticated, being mistaken for catarrh, and is often recovered from. The diagnosis can be made by injecting a guinea-pig with the nasal mucus.

Acute and Chronic Farcy.—Acute farcy arises at the site of a skin-

inoculation; it begins as an intense inflammation, from which emerge inflamed lymphatics that present nodules or "*farcy-buds.*" Abscesses form. There are joint-pains and the constitutional symptoms of sepsis, but no involvement of the nares. Chronic farcy may last for months. In it nodules occur upon the extremities, which nodules break down into abscesses and eventuate in ulcers resembling those of tuberculosis.

Treatment.—In treating this disease the point of infection is at once to be incised and cauterized, dusted with iodoform, and dressed antiseptically. The skin over enlarged glands and swollen lymphatics is to be painted with iodin and smeared with ichthyol. Bandages are applied to edematous extremities. Ulcers are curetted, touched with pure carbolic acid, dusted with iodoform, and dressed antiseptically. In glanders the nostrils should be sprayed at frequent intervals with peroxid of hydrogen, and frequently syringed with a solution of sulphurous acid. The mouth must be rinsed repeatedly with solutions of chlorate of potassium. Abscesses are to be opened, mopped with pure carbolic acid, and dressed antiseptically. Stimulants and nourishing diet are imperatively demanded. Morphin is necessary for the muscular pain, restlessness, and insomnia. Digitalis is given to stimulate the circulation and kidney secretion. Sulphur iodid, arsenite of strychnin, and bichlorate of potassium have been used. Diseased horses ought at once to be killed and their stalls should be torn to pieces, purified, and entirely rebuilt. A man with chronic glanders should be removed to the seaside. The nasal passages must be kept clean and the ulcers must be cauterized and dressed with iodoform gauze. Nutritious foods, tonics, and stimulants are necessary.

Actinomycosis is a specific infectious disorder characterized by chronic inflammation, and is due to the presence in the tissues of the *actinomyces* or ray-fungi. As stated on page 18 the ray-fungus occupies a position between bacteria and moulds and more than one variety of the fungus exists. Some of the varieties are pathogenic, others do not seem to be. It is anaërobic but when dried is not at once killed, but months after may develop if placed under favorable conditions. When growing in the tissues it usually forms numerous distinct aggregations each about the size of a sand grain and called from their color *sulphur grains*. Usually the growths lie in purulent matter. If purulent matter containing growths is rubbed between the fingers it will give a gritty sensation like sand, if the growth is not very recent. The growth of the fungi causes the formation of an infective granuloma and great masses of granulation tissue may form with collections of necrotic or purulent matter here and there, and zones of fibrous tissue. The fungi are easily discovered in the sulphur grains with the microscope. This disease occurs in cattle (*lumpy jaw*) and in pigs, and can be transmitted to man, usually by the food. At the point of inoculation (which is generally about the mouth) arises an infective granuloma, around which inflammation of connective tissue occurs, suppuration eventually taking place. Inoculation in the mouth is by way of an abrasion of mucous membrane or through a carious tooth. Chewing straw which contains the fungi is the most common method of infection. The ray-fungi may pass into the lungs, causing pulmonary actinomycosis; into the intestines, causing intestinal actinomycosis; into the skin, the bones, the subcutaneous tissues, the heart, the brain, the liver, the urinary organs, etc. Abdominal anthrax is the commonest form and comprises nearly 50

per cent. of cases. Cases of human actinomycosis until very recently were looked upon as sarcomata. Many sinuses form, but large abscesses do not arise.

The pus of actinomycosis contains many sulphur-yellow bodies visible to the naked eye and composed of fungi. These bodies usually feel gritty when rubbed between the fingers because of the presence of lime salts.

In actinomycosis the adjacent lymph-glands are very seldom involved, and if metastasis occurs it takes place by the veins. The condition causes but slight pain. A diagnosis must be made from syphilis, sarcoma, and tuberculosis. The formation of a tumor, followed by sinuses and ulceration, the ulcer having undermined edges and edematous granulation, and adjacent pus cavities joining by sinuses, the appearance of the pus, and the microscopic study of the discharge are significant. It is well to remember that an individual with actinomycosis may react to tuberculin like a person with tuberculosis. Actinomycosis may last for years, or it may prove fatal.

Cutaneous actinomycosis may be secondary to visceral infection with the disease, may be a purely local condition, or may be associated with some adjacent area of bone-infection. The gummatous form of actinomycosis resembles a gummatous syphilitic area, and in it many small purulent pockets open by fistulæ (Monestié).

In the anthracoid form there are no distinct purulent collections, but many fistulæ discharge pus at various points (Monestié).

An area of cutaneous actinomycosis is characterized by the existence of violet, blue, gray, or black maculæ, varying in size from that of a pin's head to that of a bean, the center of each macule being white and containing a minute quantity of pus (Derville).

In actinomycosis of bone the bone enlarges and becomes painful, the parts adjacent swell from infiltration and soften, pus forms and reaches the surface through fistulæ, and the skin becomes involved secondarily.

Abdominal actinomycosis takes origin from the gastro-intestinal tract, an actinomycotic nodule of the intestine having ulcerated, adhesions having formed, and an actinomycotic abscess having arisen, or actinomycotic disease of the intestine having spread. In over fifty per cent. of cases of abdominal actinomycosis the cecum is the part attacked. A fecel fistula may form and the liver may be involved. The mortality of actinomycosis depends upon the site of infection, the question of secondary infection, and the plan of treatment. If pyogenic infection occurs fatal pyemia may arise. The prognosis is reasonably good in many cases. The majority of cutaneous cases (nearly 90 per cent.) and many osseous cases can be cured. The mortality in the abdominal cases is large. Grill says that of 77 abdominal cases treated surgically 45 died, 22 recovered, and 10 were improved. Frazier ("Keen's System of Surgery") tells us that the mortality of the reported cases of actinomycosis in the United States was 47 per cent. and quotes Jiron as follows regarding the mortality of the various forms: Face and neck, 11 per cent.; thorax, 83 per cent.; abdomen, 71 per cent.; brain, 100 per cent. Actinomycosis has a strong tendency to redevelop even after apparently thorough excision. A case of cutaneous actinomycosis of the arm, seen by the author, was operated on twenty times. Ulceration took place into the axillary artery and death was narrowly averted. Recovery finally ensued. I have seen three cases of human

actinomycosis; one was the patient just referred to; another was a mattress stuffer (straw being used), his lesion was on the chest and jaw and recovery followed operation; the third was a stable hand, who died from a lesion of the face, jaw, and neck.

Treatment.—Free excision if possible; otherwise incision, scraping, cauterization with pure carbolic acid or silver nitrate, and packing with iodoform gauze. If possible remove the entire area, if not possible remove all we can. Sinus must be widely opened, each collection of pus must be drained, and granulation tissue if not extirpated must be scraped away with a sharp spoon. Give internally large doses of iodid of potassium. This drug alone has cured many cases. It is given for a week or two and is then discontinued for one week. Cases of actinomycosis should be placed under the best hygienic conditions, should live, as far as possible, in the sunlight and open air, and should be given nutritious diets, tonics, and often stimulants.

XVI. SYPHILIS.

Definition.—Syphilis is a chronic contagious, and sometimes hereditary, constitutional disease. It was long believed that only members of the human family could take syphilis, but Metschnikoff and Roux have succeeded in inoculating chimpanzees ("Annals of Pasteur Institute," Dec., 1903). Its first lesion is an infecting area or chancre, which is followed by lymphatic enlargements, eruptions upon the skin and mucous membranes, affections of the appendages of the skin (hair and nails), "chronic inflammation and infiltration of the cellulovascular tissue, bones, and periosteum" (White), and, later, often by gummata. This disease is probably due to a microbe, but Lustgarten's bacillus has not been proved to be the cause. One fact against its being the cause is its presence in the non-contagious late gummata. The spirochæta pallida occurs in the contagious lesions and there is considerable evidence that it is the real cause (page 48). White quotes Fenger in his assumption that syphilitic fever is due to absorption of toxins; that the eruptions of skin and mucous membranes in the secondary stage arise from local deposit and multiplication of the virus; that many secondary symptoms result from nutritive derangement caused by tissue-products passing into the circulation; that the virus exists in the body after the cessation of secondary symptoms; and that it may die out or may awaken into activity, producing "*reminders*."

During the primary and secondary stages fresh poison cannot infect, and this is true for a long time after the disappearance of secondary symptoms. Immunity in the primary stage is due to products absorbed from the infected area. Colles's immunity is that acquired by mothers who have borne syphilitic children, but who themselves show no sign of the disease. Profeta's immunity is the immunity against infection possessed by many healthy children born of syphilitic parents. Tertiary syphilitic lesions are not due to the poison of syphilis, but to tissue-products resulting from the action of that poison, or to nutritive failure as a consequence of the disease. Tertiary syphilis is not transmissible, but it secures immunity.

Transmission of Syphilis.—This disease can be transmitted—(1) by contact with the tissue-elements or virus—*acquired* syphilis; and (2) by

hereditary transmission—*hereditary* syphilis. The poison cannot enter through an intact epidermis or epithelial layer, and abrasion or solution of continuity is requisite for infection. Syphilis is usually, but not always, a venereal disease. It may be caught by infection of the genitals during coition, by infection of the tongue or lips in kissing, by smoking poisoned pipes, by drinking out of infected vessels, or by beastly practices. Syphilis not due to sexual relations is called *syphilis of the innocent.* The barber is a danger, and cases are reported as following razor cuts and particularly the application of the alum stick to arrest bleeding. This stick is used over and over again and dried blood is often to be found upon it. I was consulted by a man who had been thus infected. I have treated two young girls infected by dentist's instruments, a policemen infected by a pipe, a glassblower infected from the blowpipe, and a street car driver who got the disease from a borrowed whistle. Bulkley ("Jour. Am. Med. Assoc.," March 4, 1905) collected 1863 cases following vaccination; 179 following circumcision; 82 following tattooing, and 745 following cupping or venesection. The initial lesion of syphilis may be found on the finger, penis, eyelid, lip, tongue, cheek, palate, labium, vagina, anus, nipple, etc. Bulkley found that in 1810 cases the chancre was on the lip, in 1148 on the breast, in 734 in the mouth, in 432 on the hand or one of the fingers, in 372 about the region of the eye, and in 307 on the tonsil (F. D. Patterson, in "Therapeutic Gazette," Nov. 15, 1905). A person may be a host for syphilis, carry it, give it to another, and yet escape it himself (a surgeon may carry it under his nails, and a woman may have it lodged in her vagina). Syphilis can be transmitted by vaccination with human lymph which contains the pus of a syphilitic eruption or the blood of a syphilitic person. Vaccine lymph, even after passage through a person with pox, will not convey syphilis if it is free from blood and the pus of specific lesions; it is not the lymph that poisons, but some other substance which the lymph may carry.

Syphilitic Stages.—Syphilis was divided by Ricord into three stages: (1) the *primary* stage—chancre and indolent bubo; (2) the *secondary* stage —disease of the upper layer of the skin and mucous membranes; and (3) the *tertiary* stage—affections of connective tissues, bones, fibrous and serous membranes, and parenchymatous organs. This division, which is useful clinically, is still largely employed, but it is not so sharp and distinct as was believed by Ricord; it is only artificial. For instance, ozena may develop during a secondary eruption, and bone disease may appear early in the case.

Syphilitic Periods.—White divides the pox into the following periods: (1) period of *primary incubation*—the time between exposure and the appearance of the chancre; from ten to ninety days, the average being twenty-five days; (2) period of *primary symptoms*—chancre and bubo of adjacent lymph-glands; (3) period of *secondary incubation*—the time between the appearance of the chancre and the advent of secondary symptoms: about six weeks as a rule; (4) period of *secondary symptoms*—lasting from one to three years; (5) *intermediate* period—there may be no symptoms or there may be light symptoms which are less symmetrical and more general than those of the secondary period: it lasts from two to four years, and ends in recovery or tertiary syphilis; (6) period of *tertiary symptoms*—indefinite in duration. The fifth and sixth periods may never occur, the disease having been cured.

Primary Syphilis.—The primary stage comprises the chancre or infecting sore and bubo. A chancre or initial lesion is an infective granuloma resulting from the poison of syphilis and is most usually met with upon the genital organs. A chancre may be derived from the discharges of another chancre, from the secretion of mucous patches and moist papules, from syphilitic blood, or from the pus or secretion of any secondary lesion. Tertiary lesions cannot cause chancre. It appears at the point of inoculation (page 275), and is the first lesion of the disease. During the three weeks or more requisite to develop a chancre the poison is continuously entering the system, and when the chancre develops the system already contains a large amount of poison. A chancre is not a local lesion from which syphilis springs, but is a local manifestation of an existing constitutional disease, hence excision is entirely useless. If we take the discharge of a chancre and insert it at some indifferent point, into the person from whom we took it, a new indurated chancre will not be formed, because the individual already has syphilis, but auto-inoculation with the discharge of an *irritated* chancre can cause a *non-indurated* sore. If we take the discharge of a chancre and insert it into a healthy person, an indurated chancre follows. Hence we say that primary syphilis is not auto-inoculable, but is hetero-inoculable. A soft sore can be produced in the lower animals by inoculation with the virus of a chancre, but a hard sore cannot except in chimpanzees. Some observers, notably Kaposi, of Vienna, advocate the *unity theory*. This theory maintains that both hard and soft sores are due to the same virus, the infective power of the soft chancre simply being less than that of the hard sore, the possibility of constitutional infection depending, not upon differences in the poison, but rather upon differences in the soil and in the local processes. The unicists advocate excision of chancres, soft or hard, to prevent, if possible, constitutional involvement. Most syphilographers believe in the *duality theory*, which we have previously set forth. This theory took origin from the classical investigations of Bassereau and Rollet. The duality theory maintains that the soft sore is caused by a poison different from that which originates the hard sore, and that a true soft sore never infects the system.*

Initial Lesions.—An initial lesion, hard chancre, or infecting sore never appears until at least ten days after exposure; it may not appear for many weeks, but it usually arises in about twenty-five days. There are three chief forms of initial lesion: (1) a purple patch exposed by peeling epidermis, without induration and ulceration—a rare form; (2) an indurated area under the epidermis, without ulceration—a very common form; and (3) a round, indurated, cartilaginous area with an elevated edge, which ulcerates, exposing a velvety surface looking like raw ham; it bleeds easily, rarely suppurates, does not spread, and the discharge is thin and watery. This is the "*Hunterian chancre*," which is rarer than the second variety, but commoner than the first, and which ulcerates because of dirt, caustic applications, or friction.

A chancre is rarely multiple; but if it is so, all the sores appear together as a result of the primary inoculation; they do not follow one another because of auto-infection. A hard sore does not suppurate unless irritated by caustics, friction, or dirt, or unless there be mixed infection with chancroid; its nature

* For a full discussion of these points see the writings of Fournier, Alfred Cooper, and von Zeissl, and especially the great work of Taylor.

is not to suppurate. The hardness may affect only the base and margins of an ulcer or it may affect considerable areas, but it has well-defined margins and feels like cartilage encapsuled, so that it can be picked up between the fingers. This hardness or sclerosis is due to gradual inflammatory exudation into "the tissue at the base of the ulcer and to growth of the nodule" (von Zeissl). It feels distinct from the surrounding tissues, like a foreign body lying in the part. A chancre untreated may last many months. The induration usually disappears soon after the appearance of secondary symptoms. A copper-colored spot remains, and does not disappear until the disease is cured. Induration may again appear before the outbreak of some distant lesion.

Mixed Infection of Chancre and Chancroid.—Von Zeissl says: "If syphilitic contagion is mixed with pus, a chancre begins as a circumscribed area of hyperemia and swelling, which undergoes ulceration, and does not develop hardness for a period of from ten days to several weeks, and may develop a nodule after the first ulcer has entirely healed." This condition is seen when mixed infection occurs, the chancroid poison being quick, and the syphilitic poison being slow, to act. If chancroid poison is deposited some time after the syphilitic poison has been absorbed, the induration may appear in a few days after the chancroid begins. A soft chancre may appear upon an existing syphilitic nodule and may eat out the induration.

Diagnosis of Chancre.—It is necessary to distinguish a chancre from a chancroid and from ulcerated herpes. A chancroid appears in from two to five days after contagion (always less than ten days); it may be multiple from the start, but, even if beginning as one sore, other sores appear by auto-inoculation; it begins as a pustule, which bursts and exposes an ulcer; the ulcer is circular, has thin, sharp-cut, or undermined edges, a sloughy, non-granulating base, and gives origin to a thin, purulent, offensive discharge which is both auto- and hetero-inoculable. These soft sores have no true sclerotic area, do not bleed, produce no constitutional symptoms, and are apt to be followed by acute inflammatory buboes which tend to suppurate. A chancroid causes pain, and the original ulcer enlarges greatly. A chancre appears in about twenty-five days after inoculation (never before ten days); it is generally single, but if multiple sores exist, they all appear together, for their discharge is not auto-inoculable if the sore is not irritated; an auto-inoculation of the products of an irritated chancre can at most produce only a soft purulent ulcer. A chancre begins as an excoriation or as a nodule; if an ulcer forms, its floor is covered with granulations and it is red and smooth; the discharge is thin and scanty and not offensive; the edges are thick and sloping; it is surrounded by an area of induration, and bleeds when touched, there appear about the same time with it indolent multiple enlargements of the adjacent glands, which rarely suppurate, and it is followed by secondary symptoms. A chancre causes little pain, and after it has existed for a few days rarely shows any tendency to spread. A urethral chancre appears after the usual period of incubation; it is situated near the meatus, one lip of which is usually indurated; the discharge is slight, often bloody, never purulent; indurated multiple buboes arise; the sore can be seen, and constitutional symptoms follow.

Herpetic ulceration has no period of incubation; it may follow fever, but usually arises from friction or irritation due to dirt or acrid discharges. It

appears as a group of vesicles, all of which may dry up, or some may dry up and others ulcerate, or they may run together and ulcerate. The edges of an herpetic ulcer are in "segments of small circles" (White); the ulcer is superficial, has but little discharge, and does not have much tendency to spread; it has no induration; it is painful; it is not accompanied by bubo unless suppuration is extensive. Herpes is not followed by constitutional involvement.

A chancre may be mistaken for cancer of the tongue. "A chancre of this region is brownish-red, a cancer being bright red. A chancre is soft in the center; a cancer presents uniformity of induration. A chancre gives origin to a thin, purulent discharge, free from blood; a cancer furnishes a non-purulent, bloody discharge. A chancre is soon followed by indolent lymphatic enlargements under the jaw; a cancer is followed by painful enlargements." A cancer is slower in evolution, is not followed by constitutional symptoms, and the lymphatic enlargements are much later in appearing than in chancre.

Phagedena.—A chancre or a chancroid may be attacked by phagedena, a destructive form of ulceration which was once common, but at present is rare. The ulceration often spreads on all sides and also deeply into the tissues. In some cases it spreads at the edge in one direction (*serpiginous ulceration*), in some cases sloughing occurs. Phagedena occurs only in the debilitated (anemic, drunkards, strumous subjects, sufferers from diabetes, Bright's disease, etc.; salivation can cause it). The phagedenic ulcer is irregular, with congested and edematous edges, and a foul, sloughy floor.

Chancre Redux.—Some observers believe that reinfection with syphilis is not very unusual (Hutchinson). Most authorities maintain that it is very rare (Taylor). The latter school maintains that the region once occupied by a chancre may, after many years, become indurated anew. Fournier pointed out this fact thirty years ago. Such a reinduration is called chancre redux, or relapsing chancre.

If syphilitic manifestations follow such an induration, we must conclude that reinfection has truly occurred. If they do not follow, and this is the rule, the lesion is not really a chancre, but is probably a gumma in an early stage of development. Mauriac pointed out this last fact.*

Syphilitic Bubo.—In syphilitic bubo anatomically related lymphatic glands enlarge about the same time as induration of the initial lesion begins. In the very beginning these glands may be a little painful, but the pain is slight and of temporary duration. These enlargements are called "indolent buboes"; they may be as small as peas or as large as walnuts, are freely movable, and very rarely suppurate. The lesion of the glands is hyperplasia of all the gland-elements and of their capsules, due to absorption of the virus. If the patient is tuberculous, the bubo is apt to become enormous, lobulated, and persistent. If the chancre appears on the penis, the superficial inguinal and femoral glands enlarge, usually on the same side of the body as the sore. If the sore is on the frenum, both groins are involved. If a chancre appears on the lip or tongue, the bubo is beneath the jaw. These buboes may remain for many months; they do not suppurate unless the sore suppurates or unless the patient is of the tuberculous type; and they finally disappear by absorption or fatty degeneration. About six weeks after buboes have formed in the

* Mraček, in Wien. klin. Rundschau, 1896. H. G. Antony, in Chicago Medical Recorder, April, 1899.

glands related to the lesion all the lymphatics of the body enlarge. General lymphatic involvement arises about the same time as the secondary eruption. The enlargement of the post-cervical and epitrochlear glands is diagnostically important. Glandular enlargements persist until after the eruptions have disappeared.

Glandular enlargement always occurs in syphilis, but the bubo exists in only one-third of the chancroid cases. The bubo of syphilis is multiple, consisting of a chain of movable glands (the glandulæ Pleiades of Ricord); the bubo of chancroid is one inflamed and immovable mass. The bubo of syphilis is indurated, painless, small, and slow in growth; the bubo of chancroid shows inflammatory hardness, is painful, large, and rapid in growth; the first rarely suppurates, the second often does. The skin over a syphilitic bubo is normal; that over a chancroidal bubo may become red and adherent. A syphilitic bubo is not cured by local treatment, but is cured by the internal use of mercury and is followed by secondary symptoms. A chancroidal bubo requires local treatment, is not cured by mercury, and is not followed by secondaries. Herpes, balanitis, and gonorrhea rarely cause bubo, but when they do the bubo in each case is similar to that caused by chancroid. A positive diagnosis of syphilis can be made when an indurated sore on the penis is followed by multiple indolent buboes in the groin and by enlargement of distant glands.

General Syphilis.—As the general lymphatic enlargement becomes manifest a group of symptoms known as "*syphilitic fever*" may appear. In many mild cases, however, fever is absent and the eruption is the first sign of constitutional involvement. The patient usually thinks he has a severe cold, is feverish and restless; complains of headache, lassitude, sleeplessness, and anorexia; his face is pale; he has intermitting rheumatoid pains in the joints and muscles, especially of the shoulders, arms, chest, and back, which pains change their location constantly and prevent sleep; night-sweats occur, and the pulse is quite frequent. The fever usually reaches its height in forty-eight hours, and falls as the eruption develops. The eruption develops usually in from forty-eight to seventy-two hours after the onset of the fever, but may not do so for one week or even more. The fever and the discomfort are worse at night. In type the fever may be intermittent, remittent, or continued. Prolonged syphilitic fever with delay in the appearance of the eruption gives rise sometimes to great errors in diagnosis. In syphilitic fever there are anemia, trivial leukocytosis, and a marked fall in hemoglobin. Syphilitic fever may reappear during the progress of the disease.

Secondary Syphilis.—The phenomena of secondary syphilis are due to poisoned blood. Fenger states that the poison is present in the blood during outbreaks, but not during the quiescent periods between outbreaks. Secondary syphilis is characterized by plastic inflammation, by the formation of fibrous tissue, and by thickening of tissue. Superficial ulcerations may occur. Structural overgrowths appear (for instance, warts).

Syphilitic Skin Diseases.—*Syphilodermata* (*syphilides*) are due to circumscribed inflammation, and may be dry or purulent. There is no one eruption characteristic of syphilis. This disease may counterfeit any skin disease, but it is an imitation which is not perfect and is never a counterpart. Syphilitic eruptions are often circumscribed; they terminate suddenly at their edges, and do not gradually shade into the sound skin. In color they are apt

to be brownish-red, like tarnished copper; especially is this the case in late syphilides. Hutchinson cautions us to remember that an ordinary non-specific eruption may be copper-colored, especially in people with dark complexions and when it occurs on the legs. Eruptions are apt to leave a brownish stain. Early syphilitic eruptions are symmetrical. Syphilitic eruptions have an affection for particular regions, such as the forehead, the abdomen and chest, the neck and scalp, about the lips and the alæ of the nose, the navel, anus, groins, between the toes, and upon the palms and soles. Early secondary eruptions rarely appear on the face or hands. Specific eruptions are polymorphous, various forms of eruption being often present at the same time, so that roseola is seen here, papules there, etc. These syphilides do not cause as much itching as do non-specific eruptions, except when they occur upon the scalp, about the anus, or between the toes. The late secondary eruptions tend to an arrangement in curved lines.

Forms of Eruption.—The chief forms of eruption are: (1) erythema, (2) papular syphilides, (3) pustular syphilides, and (4) tubercular syphilides. Besides these eruptions pigmentation may occur (pigmentary syphilide), and blood may extravasate (purpuric syphilide).

Prince A. Morrow does not believe in erecting the vesicular syphilides into a special group. He tells us that vesicles sometimes form on erythemato-papular lesions, but their presence is an accident and not a regular phenomenon. So, too, the bullous syphilide is a rare accident in a case, and even when it occurs soon becomes pustular. The pemphigoid syphilide is found almost exclusively in hereditary disease.*

1. **Erythema** (*maculæ*, *roseola*, or *spots*). This eruption usually comes on gradually, crop after crop of spots appearing, and many days passing before an extensive area is covered. Occasionally, however, it arises suddenly (after a hot bath, after taking violent exercise, or after eating an indigestible meal). This eruption consists of circumscribed, irregularly round, hyperemic spots, about one-eighth of an inch in diameter, whose color does not entirely disappear on pressure in an old eruption but does in a recent one. The color is at first light pink, but it becomes red, purple, or even brown. In the papular form of erythema the spots are slightly elevated. Erythema is rare upon the face and the dorsum of the hands and feet. It attacks especially the chest and belly, but appears often on the forehead, the bend of the elbow, and the inner portion of the thigh, the neck, and the flexor surface of the forearms and arms. It appears first on the abdomen and last on the legs. Usually erythema follows syphilitic fever, about six weeks after the chancre appears, and the number and distinctness of the spots are in proportion to the violence of the fever. No fever or slight fever means there will be but few spots and they will soon disappear. In rare cases the eruption is very transitory, lasting but a few hours, but it usually continues for several weeks if untreated. It may pass away or may be converted into a papular eruption. Mercury will cause it to disappear in a couple of weeks. In examining for this form of eruption in a doubtful case, let cold air blow upon the chest and belly (Hearn); this blanches the sound skin and makes clear any discoloration. No desquamation attends the macular eruption, but a brownish stain remains for a variable time after the eruption fades. Erythema means, as a rule, a mild and

* Morrow's "System of Genito-urinary Diseases, Syphilology, and Dermatology."

curable attack. Maculæ may be combined with the next form, constituting a maculopapular eruption.

The maculopapular syphilides are evolved from the macular syphilides. They are slightly elevated, are situated upon hyperemic bases, and the summits of some of them may undergo slight desquamation. A roseolar area may show one or several of these macular papules. They are apt to arrange themselves in segments of a circle, and are symmetrically distributed. This eruption usually appears early, but may appear late. It may fade and reappear several times in the same patient. The eruption lasts a few weeks.

2. **Papular syphilides,** which are papules or elevations covered with dry skin, may or may not desquamate. If they do desquamate, the process begins over the center. They usually appear from the third to the sixth month of the disease. They may be preceded by fever, and often reappear again and again. They are at first red, but become brownish. They are firm in feel and vary in size from the head of a pin to a five-cent piece or larger. They may be present as miliary papules, lenticular papules, papules which scale off (papulosquamous eruption), and moist papules. Papules on fading leave coppery-looking stains. Papules upon the palms and soles constitute the so-called "palmar and plantar *psoriasis*," which appears from three months to one year after the appearance of the chancre. Papules just below the line of the hair on the forehead constitute the *corona veneris*. Papular syphilides appear especially upon the forehead, the neck, the abdomen, and the extremities. The papular or squamous syphilide of the palms and soles begins as a red spot which becomes elevated and brownish; the epidermis thickens and is cast off, and there then remains a central red spot surrounded by undermined skin. If papules are in regions where they are kept moist (as about the anus), they become covered with a sodden gray film which after a time is cast off and leaves the papule without epidermis. The sodden papules are called *flat condylomata*, moist or humid papules or plates (Fig. 112). Papules which are at first small may become large. The small or miliary papules constitute *syphilitic lichen*. The lenticular papules are most common, and strongly tend to scale off. The papular syphilides give a worse prognosis for the constitutional disease than do spots.


Fig. 112.—Condylomata (Horwitz).

3. **Pustular syphilides** arise from papules. The condition is known as *acne* when the apex of the papule softens, *impetigo* when the whole papule suppurates, and *ecthyma* or *rupia* when the corium is also deeply involved. Vesicles occasionally precede pustules. The pustular eruption appears a number of months after infection and later than the papular. The pustular eruption gives a very bad prognosis for the constitutional disease. Rupia is formed by a pustule rupturing or a papule ulcerating, the secretion drying and forming a conical crust which continually increases in height and diameter, while the ulceration extends at the edges. When the crust is pulled off there is seen a foul ulcer with congested, jagged, and undermined edges. Rupia may be secondary or tertiary, and it invariably leaves scars. It appears only after at least six months have passed since the chancre began. Secondary rupia is symmetrical. Tertiary rupia is asymmetrical.

4. **Tubercular syphilides** are greatly enlarged papules intermediate between ordinary papules and gummata.

Diagnosis between Secondary and Tertiary Syphilides.—A secondary eruption is distinguished from a tertiary eruption by the following: the first tends to disappear, the second tends to persist and to spread; the first is general and symmetrical, the second is local and asymmetrical; the first does not spread at its edge, the second tends to spread at its edge, and this tendency, which is designated "*serpiginous,*" produces an ulcer shaped like a horseshoe (Jonathan Hutchinson). Secondary lesions appear within certain limits of time, develop regularly, and are dispersed by mercurial treatment. Tertiary lesions appear at no fixed time, develop irregularly, and are not cleared up by mercury.

Affections of the Mucous Membranes.—The chief lesions in syphilitic affections of the mucous membranes are mucous patches, warts, and condylomata. The first phenomena of secondary syphilis are, as a rule, symmetrical ulcers of the tonsils, painless, of temporary duration, and superficial (Hutchinson). The borders of the ulcers are gray, and the areas are reniform in shape. Catarrhal inflammations often occur. Eruptions appear on the mucous membranes as upon the skin. *Mucous patches* are papules deprived of epithelium; they are gray in color, are moist, and give off an offensive and virulent discharge. They usually appear as areas of congestion, swelling, and abrasion of the epidermis upon the lips, palate, gums, tongue, cheeks, vagina, labia, vulva, scrotum, anus, and under the prepuce. A moist papule of the skin is really a mucous patch. These patches, which are always circular or oval, are among the most constant lesions of the secondary stage, appearing from time to time during many months. If a patch has the papillæ destroyed, it is called a "*bald patch.*" If the papules present hypertrophied papillæ fused together, there appear enlargements with flat tops, termed *condylomata;* if the papillæ of the papules hypertrophy and do not fuse, the growths are called *warts* (Fig. 134). Mucous lesions of the mouth are commonest in smokers and in those with bad or neglected teeth. Hutchinson says that persistence in smoking during syphilis may cause leukomata, or persistent white patches. The vagina and lips of the vulva during the secondary stage are often covered with mucous patches. The uterus may contain mucous lesions which poison the uterine discharge. The larynx may suffer from inflammation, eruptions, and ulceration (hence the hoarse voice which is so usual). The nasal mucous

membrane may also suffer. The rectal mucous membrane may be attacked with patches, and so may the glans penis, the inner surface of the prepuce, and the urethra. Early in the secondary stage in some cases there is a slight muco-purulent urethral discharge, and examination with an endoscope shows redness of the mucous membrane of the anterior urethra. The discharge is contagious. The condition may be followed by constriction of the urethral caliber. Distinct ulceration may take place.

Affections of the Hair.—In syphilis the hair is usually shed to a great extent. This loss may be widespread (beard, mustache, head, eyebrows, pubic hair, etc.) or it may be limited. Complete baldness sometimes ensues, but it is rarely permanent. The hairs of the head are first noticed to come out on the comb; on pulling them they are found loose in their sheaths—so loose that Ricord has said "a man would drown if a rescuer could pull only upon the hair of the head." The falling out of the hair, which is known as *alopecia*, usually begins soon after the fever or about the time of the eruption, but it may be postponed until much later. The skin of a syphilitic bald spot is never smooth, but is scaly. The hair may thin generally, baldness may appear in twisting lines, or it may be complete only in limited areas. Alopecia results from shrinking of the hair-pulp, death of the hair, and casting off of the sheath.

Affections of the Nails.—*Paronychia* is inflammation and ulceration of the skin in contact with a nail and extending to the matrix. The nail is cast off partially or entirely. *Onychia* is inflammaion of the matrix, and is manifested by white spots, brittleness or extended opacity, twisting, and breaking off of the nail. The parts around are not affected. The damaged nail drops off and another diseased nail appears.

Affections of the Ear.—Temporary impairment of hearing in one or both ears is not uncommon in syphilitic affections of the ear. Rarely, permanent symmetrical deafness is produced. Ménière's disease is sometimes caused by syphilis.

Affections of the Bones and Joints.—In syphilis there may be slight and temporary periostitis. Pain and tenderness arise in various bones, the pain being worse at night (*osteocopic pains*). Osteoperiostitis usually arises with or after the onset of the secondary eruption, but in rare instances precedes the syphilides. The bones usually involved are the tibiæ, clavicles, and skull. Intense headache may be due to periostitis of the inner surface of a cranial bone (Mauriac). Local periostitis may form a *soft node* which by ossification becomes a *hard node*. Pain like that of rheumatism may affect the joints. It is not increased by motion and is worse at night. Such pains are by no means uncommon and in some cases are very severe. The joints are not stiff except perhaps on rising. Paton reminds us that such arthralgia is an early symptom and may actually antedate the secondary eruption ("Brit. Med. Jour.," Nov. 28, 1903). More common than the above condition is synovitis, acute or chronic. It often comes on rapidly without other symptoms and is announced by swelling, tenderness, and pain. In some cases the pain is severe, and the patient is feverish or actually ill. Such cases constitute what is called *syphilitic rheumatism*, but the profuse sweats of acute rheumatism are absent, the heart is never attacked, the skin is not red, the fever is not high, and the condition is not migrating (Paton, in "Brit. Med. Jour.,"

Nov. 28, 1903). Hydrarthrosis may arise in the knee as a sequence of either of the above conditions, or, late in the secondary stage, it may arise without such an antecedent trouble (Paton). Symmetrical synovitis has been noted. Secondary syphilitic disease of bone, periosteum, and joints lasts only a short time and is never destructive.

Affections of the Eye.—*Iritis* is the commonest eye trouble which may arise during secondary syphilis. It appears from three to six months after the chancre, and begins in one eye, the other eye soon becoming affected. The symptoms are a pink zone in the sclerotic, a congested, red or muddy iris, irregularity of the pupil accentuated by atropin, the existence of pain and photophobia, and sometimes hazy or even clouded pupil. Rheumatic iritis causes much pain and photophobia, syphilitic iritis comparatively little; there is less swelling in the first than in the second; the former tends to recur, the latter does not. Iritis is usually recovered from, good vision being retained. Diffuse retinitis and disseminated choroiditis never occur until a number of months have passed since the infection. The symptoms are failure of sight, muscæ volitantes, and very little photophobia. The diagnosis of retinitis and choroiditis is made by the ophthalmoscope.

Affections of the Testes.—**Syphilitic Sarcocele.**—The testicle enlarges because of plastic inflammation. Both glands usually suffer, but not always. Fluid distends the tunica vaginalis. The epididymis escapes. The testicle is not the seat of pain, is troublesome because of its weight, and has very little of the proper sensation on squeezing. The plastic exudate is generally largely absorbed, but it may organize into fibrous tissue, the organ passing into atrophic cirrhosis.

Intermediate Period.—Secondary lesions cease to appear in from eighteen months to three years. In the intermediate period no symptoms may appear, but the disease is still for some time latent and is not cured. Symptoms may arise from time to time. These symptoms, which are called "*reminders*," are not so severe as tertiary symptoms, are apt to be symmetrical, and do not closely resemble secondary lesions. Among the reminders we may name palmar psoriasis and sarcocele. Sarcocele in this stage is bilateral and rarely painful. Bilateral indolent epididymitis occasionally occurs. Sores on the tongue, a papular skin-eruption, and choroiditis may arise. Gummata occasionally occur in this stage, but they are apt to be symmetrical and non-persistent. Arteritis may occur, beginning in the intima or adventitia, and causing, it may be, aneurysm, thrombosis, or embolism. Obliterative endarteritis may cause gangrene. Vascular changes are notably common in the vessels of the brain, and thrombosis may occur, in which case paralysis comes on gradually, preceded by numbness, although sudden paralysis may take place. These paralyses may be limited, extensive, transitory, or permanent. The nervous system often suffers in this stage (anesthetic areas and retinitis). The viscera are often congested and infiltrated (tonsils, liver, spleen, kidneys, and lungs).

Tertiary Syphilis.—This stage is not often reached, the disease being cured before it has been attained. It is not so much a stage of syphilis as a condition of impaired nutrition which results from the disease. This view finds confirmation in the fact that tertiary lesions do not furnish the contagion. The primary stage disappears without treatment, the secondary stage tends

ultimately to spontaneous disappearance, but tertiary lesions tend to persist and to recur. Tertiary lesions may be single or may be widely scattered; when multiple they are not symmetrical except by accident. These lesions may attack any tissue, even after many years of apparent cure; they all tend to spread locally, they all leave permanent atrophy or thickening, they all tend to relapse, and a local influence is often an exciting cause.

Tertiary skin-eruptions are liable to ulcerate. Various eruptions may occur: papular syphilides, pustular syphilides, gummatous syphilides, serpiginous syphilides, and pigmentary syphilides. The characteristic syphilide is *rupia*, which is formed by a pustule rupturing or a papule ulcerating. A brown or black crust forms because of the drying of the discharge, ulceration continues under the crust, new crusts form, and, as the ulcer is constantly increasing peripherally, the new crusts are larger in diameter than the old ones and the mass assumes the form of a cone. An ulcer which has destroyed

Fig. 113.—Gumma of the clavicle.

the deeper layers of the skin is exposed by tearing off the crust. On healing a rupial ulcer always leaves a permanent scar.

Serpiginous ulcers are common in tertiary syphilis, and are especially common about the knees, nostrils, forehead, and lips. Serpiginous ulceration is spoken of as *syphilitic lupus*. It is preceded by a widespread brown-colored nodular cutaneous infiltration. The nodules suppurate, run together, crust, and produce an ulcer which spreads rapidly and assumes the shape of a horseshoe.

The Gumma.—The gumma is the typical tertiary lesion. In some cases there is a solitary gumma; in others, two or three or even many gummata. A gumma is a mass of granulation tissue, grayish-yellow in color, containing many cells and few fibers. Organization of the gumma fails to take place because of a want of sufficient blood-supply, the cellular mass is apt to undergo caseation, and when this occurs an ulcer forms. One portion of the mass may caseate, another portion may become fibrous. In some cases the entire gumma becomes fibrous. A gumma varies in diameter from one-eighth of an inch to two or three inches, presents a center of gummy degeneration, a surrounding area of immature fibrous tissue, and an outer zone of embryonic tissue and leukocytes. A gumma, when it is spontaneously evacuated, exhibits a small opening or many openings with very thin red and

undermined edges; the ulcer is slow to heal, and forms a thin scar, white in the center, but pigmented at the margins and usually depressed (Jonathan Hutchinson, Jr.). The *gummatous ulcer* is deep, circular in outline, with undermined edges and an uneven floor covered with a thick, white, adherent slough. Sometimes there is no slough, but an extensive area is infiltrated. A gummatous ulcer may coalesce with one or more adjacent ulcers. The discharge is scanty and tenacious. These ulcers are often seen upon the legs, and when once healed rarely recur. A gumma in the internal organs may become a fibrous mass. Gummata form in the skin, subcutaneous tissues, muscles, tongue, joints, bursæ, testes, spinal cord, brain, and internal organs. In tertiary syphilis an inflammation may not form a circumscribed gumma, but, instead, may produce a diffuse degenerating mass. This type of inflammation, which is seen in bones, is called "gummatous." A healing gumma in a mucous canal such as the rectum or larynx causes thickening and stricture. Tertiary syphilis is a common cause of amyloid degeneration and the most frequent cause of arterial and nervous sclerosis.

Various Lesions.—Hutchinson enumerates the lesions of tertiary syphilis as follows: *Periostitis*, forming nodes or causing sclerotic hypertrophy, or suppuration, or necrosis; gummata in various parts; disease of the skin of the type of rupia or lupus; gumma or inflammation of the tongue, causing sclerosis; structural changes in the nervous system, causing ataxia, ophthalmoplegia externa and interna, general paresis, optic atrophy, and paralyses of cerebral nerves; amyloid degenerations; and chronic inflammation of certain mucous membranes (of the mouth, pharynx, vagina, rectum, etc.), with thickening and ulceration. Gummatous osteoperiostitis of the vertebræ may arise, and this may be associated with disease of the membranes or cord. Syphilitic inflammation of vertebræ is called syphilitic spondylitis. Unilateral enlargement of the epididymis is sometimes noted, the mass feeling heavy, aching a little, but not being very tender. Unilateral sarcocele may be met.

Tertiary Syphilis of Bones.—The bones particularly liable to disease are the skull, sternum, nasal septum, and tibia. The usual form is a gumma, resulting in caries and necrosis. A superficial gumma causes syphilitic periostitis, a deep gumma, syphilitic osteomyelitis (McFarland's "Text-Book of Pathology"). Periostitis affects particularly the superficial bones (tibia, clavicle, sternum, ulna, etc.). It begins in the deeper layer of the periosteum, swelling arises, gummy changes occur, and the bone beneath is more or less destroyed. In the skull the bone may be completely penetrated. Not unusually syphilitic periostitis arises at the seat of a trivial injury. Syphilitic osteomyelitis occurs particularly in the phalanges and skull. An area of syphilitic bone disease may undergo repair, osteosclerosis usually and osteoporosis sometimes resulting (McFarland).

Tertiary Syphilis of Joints.—(See the careful study of E. Percy Paton, in "Brit. Med. Jour.," Nov. 28, 1903). The knee-joint is most commonly affected. Chronic synovitis may arise with considerable or even great swelling (hydrarthrosis), trivial pain, slight functional impairment, some thickening of synovial membrane, and some harshness or grating on movement (Paton). Gummatous synovitis may arise, a condition which sometimes follows the ordinary synovitis but more often exhibits very little swelling. The synovial membrane exhibits irregular areas of thickening and the symptoms resemble those of a tuberculous joint (Paton).

In some syphilitic joints the disease begins in the bone and cartilage. In such a condition there is rigidity, marked limitation of movement, pains not often severe, and some deformity (Paton). Again, as Paton points out, a joint may be involved by an adjacent syphilitic area, synovitis arising, or, if a gumma breaks into a joint, secondary pyogenic infection may follow. Ankylosis may follow joint syphilis.

Visceral Syphilis.—Amyloid changes may occur in any of the viscera of an individual with tertiary syphilis, and such changes may be found in people in whom suppuration never occurred. The lungs may undergo fibroid induration (syphilitic phthisis). Syphilitic phthisis is a non-febrile malady. Gummata may form in the heart, liver, spleen, or kidneys. The capsule and fibrous septa of the liver may thicken, the organ being puckered by contraction. Albuminuria may occur in tertiary syphilis. It may be caused by fibroid changes in the kidneys, by the formation of gummata, or by amyloid degeneration. Its occurrence should be watched for. Mercury and iodid of potassium have been regarded as causative of albuminuria in some cases.

Syphilis may cause disease of the stomach, and probably does so more frequently than was formerly supposed, because it is difficult to distinguish from more common diseases. The condition may be gummatous infiltration of the walls of the stomach, multiple and minute gummata, ulcerations resulting from breaking down of gummata, or syphilitic endarteritis of the gastric vessels. When ulcers heal cicatricial contraction results. Syphilitic ulcers and gummata of the stomach may be cured by efficient antisyphilitic treatment. Like lesions may form in the intestines. Flexner, Mraček, Fränkel, Fournier, and others have discussed this subject.*

Nervous syphilis may be manifested by disorders of the brain, cord, or nerves. It is rare after severe secondaries, and is most common when secondaries were light or so trivial as to have escaped observation. Severe secondaries seem to cast off, mitigate, or exhaust the poison. Nervous syphilis may result directly from the specific disease, and such lesions are truly syphilitic. It may result indirectly from the specific disease, and such lesions are called parasyphilitic. For instance, a gumma of the brain is a true syphilitic lesion, but locomotor ataxia following syphilis is a parasyphilitic lesion. Syphilitic lesions are improved or cured by antisyphilitic treatment, parasyphilitic conditions are not. Brain syphilis is usually a late phenomenon (from one to thirty years after infection). The lesion may be gumma of the membranes (tumor), gummatous meningitis, arterial atheroma, or obliterative endarteritis. A gumma may eventuate in a scar, a cyst, or a calcareous mass. The symptoms of brain syphilis depend on the nature, seat, and rate of development of the lesions. It is to be noted that syphilitic palsy is apt to be limited, progressive, and incomplete. Epilepsy appearing after the thirtieth year is very probably specific if alcohol as a cause can be ruled out. Persistent headache, tremor, insomnia or somnolence, transitory, limited, and erratic palsies, unnatural slowness of utterance, amnesia, vertigo, and epilepsy are very suggestive of syphilis. Sudden ptosis is very significant; so is sudden palsy of one or more of the extrinsic eye-muscles. In syphilitic insomnia the patient cannot get to sleep at night for a long while, but when he once gets to sleep he reposes well. The type of insanity which is most apt to arise is a likeness or counterpart of general paralysis, and, like ordinary paresis, it is not curable.

* See editorial in Jour. Amer. Med. Assoc., March 24, 1900.

Spinal syphilis may cause sclerosis, a condition like Landry's paralysis, softening, and tumor. Neuritis is not uncommon in syphilis. Many of the diseases which follow syphilis are due to it only indirectly, and are not benefited by specific treatment. Among them are paresis and locomotor ataxia.

Justus's Test for Syphilis.—The test consists in first estimating the amount of hemoglobin present, then making a single mercurial inunction, and again estimating the hemoglobin. It is claimed that the corpuscles of an untreated syphilitic are unduly sensitive, and if the disease is present a mercurial inunction will cause a loss of 10 to 20 per cent. of hemoglobin within twenty-four hours, which fall persists a few hours and is then followed by a rise to a level above that which existed when the test was applied. It is often demonstrable in secondary, tertiary, or congenital syphilis. It usually fails in latent cases and in early secondary syphilis, and in some diseases other than syphilis the reaction can be obtained. I regard the test as unreliable.

Treatment of the Primary Stage.—A chancre should not be excised. The disease is constitutional when the chancre appears, and excision and cauterization inflict needless pain and do no good. The initial lesion should never be cauterized unless it is phagedenic or becoming so. Order the patient to soak the penis for five minutes twice daily in warm salt water (a teaspoonful of salt to a cupful of water), and then to spray the sore with peroxid of hydrogen diluted with an equal bulk of water. The ulcer is then dried with absorbent cotton and on it is dusted a powder composed of equal parts of bismuth and calomel. The buboes in the groin require no local treatment unless they tend to suppurate. If they persist or become large, paint them with iodin or rub ichthyol ointment or mercurial ointment into them, and apply a spica bandage to the groin. Some authorities give mercury in this stage in order to prevent secondaries. The younger Gross opposed this strongly, and affirmed a wish to see the secondary eruption—first, because it proves the diagnosis; and, second, because it affords valuable prognostic indications (an erythematous eruption means a light case, an early pustular eruption means a grave case with serious complications); I have always followed the plan of Gross, and do not order mercury until constitutional symptoms develop. If phagedena arises, place the patient at once upon stimulants and nutritious diet, secure sleep, and destroy the ulcer by the use of nitric acid or the cautery while the patient is anesthetized. After cauterization dust the sore with iodoform and dress with wet antiseptic gauze. Several times a day change the dressings, and at each change spray the sore with peroxid of hydrogen, irrigate with bichlorid of mercury solution, and dust with iodoform. It may be necessary to cauterize several times. In some cases it will be necessary to employ continuous irrigation with an antiseptic fluid. These cases are sometimes fatal and usually produce great destruction of tissue. In chancre redux watch carefully for the symptoms in order to determine if the condition is really one of reinfection or if we are dealing with a gumma which resembles a chancre in appearance.

Treatment of the Secondary Stage.—The chance of cure in most cases is excellent if the patient follows advice. The prognosis is much worse if the patient is a hard drinker or is the victim of Bright's disease, diabetes, tuberculosis, or other chronic exhausting malady. In the secondary stage the aim is to cure the disease. That it can be cured is known because reinfection occurs in some persons. The old axiom, "Syphilis once, syphilis ever," is not true.

Diet and General Care.—In the beginning of treatment the patient must see his physician every day or two until the proper dose of mercury has been ascertained. For the following six months he should see his physician once a week, and during the next six months once every other week. During the second year he needs to see him once every month. Of course, if complications arise at any period the visits must be more frequent. At the beginning of the attack he must have his teeth put in perfect order. Tobacco is absolutely forbidden because its use favors the development of mucous patches in the mouth. Alcohol as a beverage is prohibited. It is used only as a medicine. The teeth should be gently scrubbed with a soft brush in the morning, in the evening, and after each meal, and a mild astringent or antiseptic mouth-wash is to be used several times a day. The patient should wear flannel in winter. The author believes Guiteras's rules are sound, and in accordance with them directs the patient to refrain from kissing any one on the lips and from using a common towel, wash-rag, cup or glass, pipe or razor. He is told to sleep alone in bed, to wash his hands often, to wear gloves, and to keep his fingers out of his mouth. Every morning he should take a warm bath, being especially careful to cleanse the anus, perineum, axillæ, groins, and between the toes; and after the bath these parts should be dusted with borated talc powder. A Turkish bath once a week is ordered by Guiteras when no skin-eruption exists. The patient must avoid drafts, cold and wet; must take a moderate amount of gentle outdoor exercise, and must sleep eight hours out of the twenty-four. The diet is of importance, and in this, too, the author follows Guiteras and orders the patient to avoid eating anything fried, or any meat or fish which has been canned, salted, or preserved. Fruits, pickles, tea, condiments, alcoholic beverages, clams, pork, veal, and pastry are not to be taken. (See article by Luke Begg in "Phila. Med. Jour.," June 7, 1901.)

Medical Treatment.—Mercury must be used, the form being a matter of choice. Fournier advocated intermittent treatment. In this plan give gr. $\frac{1}{3}$ of protiodid of mercury daily for six months, then stop for a month; then give mercury for three months, then stop two months. During the first year the patient is under treatment nine months, and during the second year eight months. Some prefer the intermittent and others the continuous plan of treatment. The author prefers the continuous plan. In following the continuous plan find the patient's tolerance to mercury, and keep him for two years on daily doses below the amount he will tolerate. Gross's rule for continuous treatment is to order pills of green iodid of mercury, each pill containing gr. $\frac{1}{5}$. The patient is ordered one pill after each meal to begin with; the next day the after-breakfast dose is increased to two pills; the following day the after-dinner dose is two pills, and so on, one pill being added every day. This advance is continued until there is slight diarrhea, griping, a metallic taste, or tenderness on snapping the teeth together, whereupon one pill is taken off each day until all unfavorable symptoms disappear. Then the dose is reduced one-half and this amount is called the tonic dose. This experimentation finds a dose on which the patient can be kept with entire safety for a long time; but if it is found that colic or diarrhea is apt to recur, there must be added to each pill gr. $\frac{1}{12}$ of opium. The patient is given mercury in this way for two years. Every time new symptoms appear the dose

is raised, and as soon as they disappear it is lowered to the standard. If the protiodid is not tolerated, give the bichlorid:

℞ Hydrarg. chlor. corros.,	gr. j;
Syr. sarsaparillæ comp.,	f ℥ iij.—M.
Sig.—f ʒ, in water, after meals.	

Mercury with chalk in 1- or 2-grain doses four times a day, with or without Dover's powder in 1-grain doses, may be used. Mercurial inunctions produce a rapid effect, but irritate the skin. The drug should be rubbed in with a gloved hand. There can be used once a day ½ dram of oleate of mercury (10 per cent.) or 1 dram of mercurial ointment, rubbed into the skin. The first day it is rubbed into the inside of one thigh, the second day into the inside of the other thigh; the third day into the inside of one arm; the fourth day into the other arm; next, into one groin and then into the other groin, and then inunction is again made at the point of original application, and so on. After the rubbing the patient puts on underclothes and goes to bed, and in the morning takes a bath. The ointment may be smeared on a rag, which is then worn between the stocking and sole of the foot during the day.

Fumigation is performed by volatilizing each night ʒj of calomel. The patient sits naked on a cane-seat chair, and is wrapped up to the neck in a blanket which drops tent-like to the floor; the calomel is put upon an iron plate under the chair, and is heated by an alcohol lamp beneath the plate. The skin becomes coated with calomel, and the subject, after putting on woolen drawers and an undershirt, gets into bed. Hypodermatic injections of mercury are used by some physicians. They cause an eruption to disappear rapidly, but may produce abscesses, and relapses are prone to occur. I agree with Dr. Orville Horwitz that the hypodermatic method will not abort the disease; should never be a routine treatment; in suitable cases it is very valuable for symptomatic use, as when lesions on the face or in important structures make a rapid impression desirable or necessary; in cases which obstinately relapse under other treatment, and in syphilis of the nervous system. J. William White, after a large experience with this method, says that hypodermatic injections of corrosive sublimate are painful and are strongly objected to by many patients; that this method of treatment is occasionally dangerous and even fatal; that it is liable to be followed by local complications (erythema, nodosities, cellulitis, abscess, sloughing); that it cannot be carried out by the patient, but requires the surgeon's constant intervention. This syphilographer concludes that hypodermatic medication does not offer advantages justifying its use as a systematic method of treatment, and that it encourages insufficient treatment—those "short heroic courses" which Hutchinson shows are followed by the gravest tertiary lesions. "The claim that by a few injections the time of treatment can be measured by months or even by weeks, instead of by years, would seem, as Mauriac has said, to involve the idea that mercury given hypodermatically acquires some new and powerful curative property which, given in other ways, it does not possess." * The usual plan is to give daily a hypodermatic injection of corrosive sublimate deep into the back or buttock, the dose being gr. ¼ of the drug. Thirty such injections are used unless some contraindication demands their discontinuance sooner. The

* J. William White, in Morrow's "System of Genito-urinary Diseases, Syphilology, and Dermatology."

treatment is then stopped. If the symptoms recur, however, the patient is given another course, the daily dosage being gr. $\frac{1}{6}$, the treatment being again stopped after thirty injections, but being continued anew in $\frac{1}{8}$-grain doses if the symptoms recur. The following preparation is used by some syphilographers: 0.5 of a part of corrosive sublimate, 3 parts of guaiacol, and 97 parts of sterile olive oil. Thirty minims contains gr. $\frac{1}{16}$ of corrosive sublimate. This mixture should be thrown deeply into the buttock and it causes no pain. The use of gray oil hypodermatically has warm advocates. It is claimed that it provokes but little pain and irritation, and that it is a very efficient remedy. The oil must be warmed and shaken before being used. Lang injects gr. $\frac{3}{4}$ to gr. $1\frac{1}{2}$ of the 50 per cent. gray oil, or twice this quantity of the 30 per cent. oil, twice during the first week, once during the second week, and after this once a week or once every other week for an indefinite period of time. It may be given oftener if symptoms arise or persist.

Taylor believes that gray oil may give rise to unpleasant and sometimes even to dangerous symptoms, and that it should be used with extreme care and only in selected cases in which other remedies are contraindicated. He says that in reading about the hypodermatic method he has been struck with the fact that "the most serious results have almost invariably followed injections in which fatty matters have been the vehicle of suspension." *

Some surgeons employ intravenous injections of mercury. Lane injects, at first every other day and later daily, 20 ♏ of a 1 per cent. solution of cyanid of mercury. The skin in front of the elbow is rendered aseptic, a fillet is tied around the arm, the needle is inserted into a vein, the fillet is loosened, the fluid is injected, and the needle is withdrawn. This method of using mercury is painless and produces a rapid effect. It may be used in nervous syphilis, but should not be used as a routine. In whatever way mercury is given, do not allow it to produce salivation (hydrargyrism or ptyalism). Always remember that mercury may cause albuminuria and examine the urine at regular intervals during a course of the drug. If albumin appears in the urine, cut down the dose of mercury or stop the drug for a time. In the beginning of a case of syphilis, if the kidneys are found to be diseased, give the mercury cautiously, and never fail to examine the urine at regular intervals. An individual can take more mercury in summer than in winter because during the warm weather perspiration favors elimination.

Throughout the mercurial course the patient should be weighed once a week, and if it is at any time found that the weight is decreasing, tonics, concentrated food, and cod-liver oil are ordered. If the weight continues to grow less and the health begins obviously to fail, stop the mercury for a time, continue the cod-liver oil, tonics, and nourishing food, and order hot baths, fresh air, iron, and chlorid of gold and sodium. In order to cure syphilis mercury should be given for two years, and the mercurial course must be followed by at least a six months' course of iodid of potash. Reminders require both iodid of potash and mercury (mixed treatment).

Acute Ptyalism, or Salivation.—In acute ptyalism the saliva becomes thick and excessive in amount; the gums become spongy and tender and liable to bleed. Tenderness is detected early by snapping the teeth. A metallic taste is complained of; the breath becomes fetid; the oral structures

* "Venereal Diseases," by Robert W. Taylor.

swell; the teeth loosen; the saliva is produced in great quantity; and there are purging, colic, and exhaustion. Sometimes there are fever and a diffuse scarlatiniform eruption upon the skin. A chronic hydrargyrism may be shown by salivation, gastro-intestinal disorder, emaciation, mental depression, weakness, albuminuria, and tremor. To avoid salivation, advance the dose with great caution and instruct the patient as to the first signs of the trouble. He should use a soft toothbrush and an astringent mouth-wash (gr. xlviij of boric acid to ℥iv each of Listerine and water). When ptyalism is noted, discontinue the administration of the drug. Employ the above mouth-wash or one composed of a saturated solution of chlorate of potassium. Order gr. $\frac{1}{120}$ of atropin twice a day, and in bad cases spray the mouth with peroxid of hydrogen and use silver nitrate locally (gr. xx to ℥j). Give stimulants (iron, quinin, and strychnin) and nutritious food. A weekly Turkish bath is of great service. In chronic hydrargyrism stop the administration of the drug, use tonics, stimulants, open-air exercise, Turkish baths, and nutritious food. The chlorid of gold and sodium forms a substitute for mercury. The use of iodid of potassium is of questionable value in ptyalism.

Treatment of Complications in the Secondary Stage.—The complications of the secondary stage usually require local applications in addition to general remedies. Mucous patches in the mouth should be touched with bluestone every day, an astringent mouth-wash being employed several times daily. If the patches ulcerate, they should be touched once a day with lunar caustic; if these areas proliferate, they should be excised and cauterized. Vegetations or growing papules on the skin must, if calomel powder fails to remove them, be cut away with scissors and be cauterized with chromic acid or with the Paquelin cautery. Condylomata demand washing with ethereal soap several times daily, thorough drying, dusting with equal parts of calomel and subnitrate of bismuth or with borated talcum, and covering with dry bichlorid gauze. If these simple procedures fail, excise and cauterize.

For psoriasis of the palms and soles diachylon ointment, mercurial plaster, or painting with tincture of iodin should be employed. Ulcers of paronychia are dressed with iodoform and corrosive sublimate gauze. Deep cutaneous ulcers are cleaned once a day with ethereal soap, sprayed with peroxid of hydrogen, dressed with iodoform and corrosive sublimate gauze and bandaged. When the process of granulation is well established dress with 1 part of unguent. hydrarg. nitratis to 7 parts of cosmolin. In sarcocele mercurial ointment should be rubbed into the skin of the scrotum or the testicle be strapped. In alopecia the hair should be kept short, and every night the scalp should be cleaned with equal parts of green soap and alcohol rubbed into a lather with water. After the soap has been washed out some hair tonic should be rubbed into the scalp with a sponge. A favorite preparation of Erasmus Wilson's consisted of the following ingredients:

℞.	Ol. amygd. dil.,	
	Liq. ammoniæ,	*āā* f℥j;
	Sp. rosemarini,	
	Aquæ mellis,	*āā* f℥iij.—M.
Ft. lotio.		

One part of tincture of cantharides to 8 parts of castor oil may be rubbed into the scalp. Solutions of quinin are esteemed by some. A useful wash for the

scalp is the following: ʒj of borate of sodium, ʒj of spirits of camphor, ʒij of glycerin, and sufficient orange-flower water to make fʒiv.

In treating persistent skin-lesions, inunctions, injections, fumigations, or mercurial baths may be used. Baths are suited to patients with delicate skins, to those whose digestion fails when mercury is given by the mouth, and to those whose lungs will not tolerate fumigations. Half an ounce of corrosive sublimate with 4 scruples of sal ammoniac are mixed in about 4 ounces of water; this is added to a bath at a temperature of 95° F. The patient gets into this bath, covers the tub with a blanket, leaving only his head exposed, and remains in the bath an hour or so. Mercurial baths may rapidly cause salivation.

Tertiary Stage.—If at any time during the case there appear tertiary symptoms, the patient should be put on mixed treatment. In any case, after two years of mercury add iodid of potassium to the treatment. White's rule is to use mixed treatment for at least six months (if any symptoms appear), the six months' course dating from their disappearance. This emphasizes the fact that the iodids alone will not cure tertiary syphilis. In obstinate tertiary lesions and in nervous syphilis the iodids should be run up to an enormous amount (from 30 to 250 grains per day). Sometimes people can take large doses of iodid when small doses produce iodism. Cyon explains this curious fact as follows: small doses combine with some products of the thyroid gland and form toxic iodo-thyrin. Large doses are diuretic, form soluble salts, and are rapidly eliminated. An easy way to give iodid is to order a saturated solution each drop of which equals about one grain of the drug. Each dose of the iodid is given one hour after meals and in at least half a glass of water. If the iodid disagrees, it may be given in water containing one dram of aromatic spirit of ammonia or in milk. The iodid of sodium may be tolerated better than the potassium salt, or the iodids of sodium, potassium, and ammonium may be combined. In giving the iodids begin with a small dose. During a course of the iodid always give tonics and insist on plenty of fresh air. Arsenic given daily tends to prevent skin-eruptions. The iodids when they disagree produce *iodism*—a condition which is made manifest by a flow of mucus from the nose, conjunctival irritation, a bad taste in the mouth, exhaustion, anorexia, nausea, and tremor. In some subjects there are outbreaks of acne, vesicular eruptions, or even bullæ or hemorrhages. Iodism calls for the abandonment of the drug, and the administration of increasing doses of Fowler's solution, of arsenic, of laxatives, of diuretic waters, or, if there is great exhaustion, of stimulants. In some cases belladonna is of service. Some patients who cannot take the alkaline iodids may take syrup of hydriodic acid. After the patient has been for six months under mixed treatment without a symptom, stop all treatment and await developments. If during one year no symptoms recur, the patient is probably cured; if symptoms do recur, there must be six months more of treatment and another year of watching.

The Question of Marriage.—Fournier has insisted that it is a great wrong to tell a syphilitic that he can never marry. He must not marry until he is cured, and he is not cured until, after the cessation of the use of iodid, he goes one year without treatment and without symptoms.

Hereditary Syphilis.—Transmitted congenital syphilis is hereditary syphilis manifest at birth. Acquired syphilis (except in the case of a woman who obtains the disease from a fetus) always presents the chancre as an initial lesion; hereditary syphilis never does. Hereditary syphilis may present itself at birth, and usually shows itself within, at most, the first six months of extra-uterine life. In rare cases (tardy hereditary syphilis) the disease does not become manifest until puberty.

Rules of Inheritance.—According to von Zeissl,* the rules of inheritance are as follows:

1. If one parent is syphilitic at the time of procreation, the child may be syphilitic.
2. Syphilitic parents may bring forth healthy children.
3. If a mother, healthy at procreation, bears a child syphilitic from the father, the mother must have latent pox or must be immune, having become infected through the placental circulation. She often shows no symptoms, having received the poison gradually in the blood, and having thus received, it may be said, preventive inoculations. Certain it is that mothers are almost never infected by suckling their syphilitic children (Colles's law).
4. If both parents were healthy at the time of procreation, and the mother afterward contracts syphilis, the child may become syphilitic, and the earlier in the pregnancy the mother is diseased, the more certain is the child to be tainted. This is known as "infection *in utero.*"
5. The more recent the parental syphilis, the more certain is infection of the offspring. The children are often stillborn.
6. When the disease is latent in the parents it is apt to be tardy in the children.
7. The longer the time which has passed since the disappearance of parental symptoms, the more improbable is infection of the children.
8. In most instances parental syphilis grows weaker, and after the parents beget some tainted children they bring forth healthy ones.

Syphilis in the mother is more dangerous to the offspring than syphilis in the father. The frequent immunity of the mother is due to the fact that her tissues produce antitoxins under the influence of the slowly absorbed virus.

Many women affected with hereditary syphilis are sterile. Many syphilitic women abort before the eighth month, most commonly in the fifth month. The fetus very often dies at an early period of gestation. This may be due to a gummatous placenta or to a degeneration of placental follicles.

Evidences of Hereditary Syphilis (manifest at, or oftener soon after, birth).—Hutchinson says that at birth the skin is almost invariably clear. In from six to eight weeks "snuffles" begin, which are soon followed by a skin-eruption, by body-wasting, and by a chain of secondary symptoms (iritis, mucous patches, pains, condylomata, etc.). The child looks like a withered-up old man. Eruptions are met with on the palms and soles. Intertrigo is usual. Cracks occur at the angles of the mouth, and leave permanent radiating scars. The abdomen is tumid, and there is apt to be exhausting diarrhea. The secreting and absorbing glands of the intestinal tract atrophy.† It is doubtful if distinct gummatous tumors form in hereditary syphilis. The type of dis-

* "Pathology and Treatment of Syphilis."
† Coutts, in Brit. Med. Jour., 1894, No. 1643.

ease induced is a diffuse interstitial cellular change in the viscera, and the viscera are much more apt to suffer than in acquired syphilis. The liver, spleen, and pancreas often enlarge from interstitial changes, and the lungs sometimes are attacked in the same manner. Sometimes synovitis or arthritis arises, the condition being similar to that met with in acquired syphilis. A form encountered between the third month and end of the second year, according to Paton, is characterized by growth into the joint of fungating granulation tissue, the joint is useless, and the parts about are swollen and edematous. Atrophic lesions may appear in the bones. In the skull the bone may be softened by removal of its salts or be thinned by the pressure of the brain. In the long bones the epiphyseal lines suffer, the attachment of the epiphyses to the shafts is weak, and separation is easily induced. Epiphysitis is common, rarely causes pain, and rarely leads to suppuration, except in children who are old enough to walk (Coutts). Osteophytic lesions of the skull are shown by symmetrical spots of thickening upon the parietal and frontal bones (*natiform skulls*). In the long bones osteophytes are frequently formed. In some cases osteophytes grow from the epiphysis, and in consequence deformity and impaired function are noted and a certain amount of ankylosis may occur. This condition of osteophytic growth from an epiphysis was called by Fournier *arthropathie deformant*. A child with precocious hereditary syphilis is apt to die, but if it lives from six months to one year the symptoms for a time disappear, and for years the disease may be latent. Diagnosis is difficult after the third or fourth year, especially if the disease be associated with rickets or tuberculosis. When later symptoms arise they may be various, namely: noises in the ears, often followed by deafness; interstitial keratitis; *dactylitis* (specific inflammation of all the structures of a finger); synovitis in any joint, particularly painless but marked symmetrical effusion in the knee-joints, with trivial functional disturbance; ossifying nodes; developmental osseous defects; suppurative periostitis; ulcerations; death of bone; falling in of the nose; nervous maladies; occasionally sarcocele, etc. In hereditary syphilis the eye-symptoms are of great diagnostic importance. In 212 cases of congenital syphilis Fournier found eye-trouble in 101. Keratitis and choroiditis are the most usual forms (Silex). Bone-trouble occurs in almost half of the cases, but is not often severe enough to cause symptoms. The tongue often shows a smooth base (Virchow's sign). Hirschberg believed choroiditis to be pathognomonic. The descendants of syphilitic parents may exhibit certain pathological conditions which are not directly syphilitic. Fournier calls such phenomena parasyphilitic. Among these phenomena are arrest of development of the body at large or of special structures, weakness of constitution, and stigmata of degeneration.

Fig. 114.—Hutchinson teeth.

Diagnosis.—In the diagnosis of hereditary syphilis the condition of the teeth is of considerable importance: the temporary teeth decay soon, but present no characteristic defect. If the upper permanent central incisors are examined, they are often, but by no means always, found defective. Other teeth may show defects, but in these alone are characteristic defects likely to appear. In hereditary syphilis they may present an appearance of marked

deviation from health, and are then called "*Hutchinson teeth*" (Fig. 114). If they are dwarfed, too short and too narrow, and if they display a single central cleft in their free edge, then the diagnosis of syphilis is probable. If the cleft is present and the dwarfing absent, or if the peculiar form of dwarfing be present without any conspicuous cleft, the diagnosis may still be made. The view that teeth of this nature *prove* the existence of hereditary syphilis and that they occur only in syphilis has been abandoned by Hutchinson himself. In fact, only one-fifth of congenital syphilitics have these teeth, and one-third of the cases of Hutchinson teeth are in individuals free from syphilis. In early infancy the diagnosis of syphilis is made by the snuffles, the broad nose, the skin-eruptions, the wasted appearance, the sores at the mouth-angles, the tenderness over bones, condylomata, and the history of the parents. The diagnosis at a later period is made by the existence of symmetrical interstitial keratitis, choroiditis, the smooth base of the tongue, deafness which comes on without pain or running from the ear, ossifying nodes, white radiating scars about the mouth-angles, sunken nose, natiform skull, deformity of long bones, painless inflammation of epiphyses, and Hutchinson teeth. It must be remembered that a child born apparently healthy and presenting no secondary symptoms may show bone-disease, keratitis, or syphilitic deafness at puberty.

Treatment.—In infants mercurial inunctions are to be used until the symptoms disappear, but mercury must not be forced or be continued too long after the symptoms are gone. There must be rubbed into the sole of each foot or the palm of each hand 5 grains of mercurial ointment every morning and night. Brodie advised spreading the ointment (in the strength of ʒ j to the ounce) upon flannel and fastening it around the child's belly. If the skin is so tender that mercury must be administered by the mouth, order that gr. $\frac{1}{12}$ to gr. $\frac{1}{2}$ of mercury with chalk, with 1 grain of sugar, be taken three times a day after nursing. If tertiary symptoms appear, and in any case when the secondaries disappear, give gr. ss to gr. j or more of iodid of potassium several times a day in syrup. White advocates the continuance of the mixed treatment intermittently until puberty. Local lesions require local treatment, as in the adult. A syphilitic child must be nursed by its mother, as it will poison a healthy nurse. If the baby has a sore mouth, it must be fed from a bottle; and if the mother cannot nurse the child, it must be brought up on the bottle. For the cachexia use cod-liver oil, iodid of iron, arsenic, and the phosphates.

XVII. TUMORS OR MORBID GROWTHS.

Division.—Morbid growths are divided into (1) neoplasms and (2) cysts.

Neoplasms.—A neoplasm is a pathological new growth which tends to persist independently of the structures in which it lies, and which performs no physiological function. We say that a tumor performs no physiological function in order to make clear that it is never a useful addition to the economy, but we must not imagine that the cells of a tumor are devoid of physiological activity. As Fütterer ("Medicine," March, 1902) has shown, the cells of a carcinoma of the liver may secrete bile, and even the cells of a secondary focus

developing in the course of hepatic carcinoma may also secrete bile. The cells of a tumor may be active, but this activity is not useful and does not constitute physiological function. A hypertrophy is differentiated from a tumor by the facts that it is a result of increased physiological demands or of local nutritive changes, and that it tends to subside after the withdrawal of the exciting stimulus. Further, a hypertrophy does not destroy the natural contour of a part, while a tumor does. Inflammation has marked symptoms: its swelling does not tend to persist, it terminates in resolution, organization or suppuration, and examination of a section of tissue under the microscope differentiates it from tumor. Inflammation, too, has an assignable exciting cause. A new growth is a mass of newly formed *tissue;* hence it is improper to designate as tumors those swellings due to extravasation of blood (as in hematocele), or of urine (as in ruptured urethra), to displacement of parts (as in hernia, floating kidney, or dislocation of the liver), or to fluid distention of a natural cavity (as in hydrocele or bursitis).

Classes of Tumors.—There are two classes of tumors; the first class includes those derived from or composed of ordinary connective tissue or of higher structures. These all originate from cells which are developed from the mesoblast. There are two groups of connective-tissue tumors: (*a*) the typical, innocent or benign, which mimic or imitate some connective tissue of the healthy adult human body; and (*b*) the atypical or malignant, which find no counterpart in the healthy adult human body, but rather in the immature connective tissues of the embryo.

The second class of tumors includes those which are derived from or composed of epithelium: (*a*) the typical, or innocent, composed of adult epithelium; and (*b*) the atypical, or malignant, composed of embryonic epithelium.

Müller's Law.—Müller's law is that the constituent elements of neoplasms always have their types, counterparts, or close imitations in the tissues, either embryonic or mature, of the human body.

Virchow's Law.—Virchow's law is that the cells of a tumor spring from pre-existing cells. There is no special tumor-cell or cancer-cell.

The starting-point of a tumor is a focus of embryonal cells, which focus may have originated before the person was born or may have resulted after birth from some disease or injury. The nature of the tumor depends first upon the embryonal layer from which it took origin. Connective-tissue tumors spring from the mesoblast; epithelial tumors spring from the epiblast or the hypoblast. The nature of the tumor depends also upon the stage in which the growth of its cells is arrested. If the cells remain embryonal, the growth is regarded as malignant; if they become fully developed, it is regarded as innocent.

The term "heterologous" is no longer used to signify that the cellular elements of a tumor have no counterpart in the healthy organism, but is employed to signify that a tumor deviates from the type of the structure from which it takes its origin (as a chondroma arising from the parotid gland). Tumors when once formed almost invariably increase and persist, though occasionally warts, exostoses, and fatty tumors disappear spontaneously. Tumors may ulcerate, inflame, slough, be infiltrated with blood, or undergo mucoid, calcareous, or fatty degeneration.

Causes.—The causes of tumors are not positively recognized, those alleged being but theories varying in probability and ingenuity.

The inclusion theory of Cohnheim supposes that more embryonic cells exist than are needful to construct the fetal tissues, that masses of them remain in the tissues, and that these embryonic cells may, later in life, be stimulated into active growth perhaps by injury or irritations or hereditary tendency. In other words, Cohnheim believes that all tumors arise from embryonal cells which were included or imprisoned by adult cells during fetal life and were not used during development; or from cells which were "displaced from their proper relations during the process of cell differentiation in the embryo" (Henry Morris, "Lancet," Dec. 12, 1903). The embryonic hypothesis seems to receive a certain force from the facts that exostoses do sometimes develop from portions of unossified epiphyseal cartilage, and that tumors often arise in regions where there was a suppression of a fetal part, closure of a cleft, or an involution of epithelium (epithelioma is usual at mucocutaneous junctions). This theory does not explain the origin of malignant tumors in scars or recent callus in parts subjected to injury or operation, etc. (Henry Morris).

Durante's addition to Cohnheim's theory does explain them. Cohnheim taught that the matrix from which a tumor springs is always an antenatal embryonic area. Durante says a tumor may also spring from a postnatal embryonic area resulting from injury of the mature tissues, lessening their activities chemical and physiological (Morris) and causing them to revert to an embryonic condition.

Objection has been made to the Cohnheim theory on the ground that an embryonal matrix could not remain quiescent, but, as Henry Morris says, certain teeth, the female mammary gland, the larynx, and certain appendages of the skin may not develop until puberty ("Bradshaw Lecture," in "Lancet," Dec. 12, 1903). Branchial cysts which are known to have such an origin are seldom seen until after puberty, and the same is true of many dermoids.

Morris shows that congenital matrices have been shown to exist in the brain, tongue, eye, testicle, ovary, broad ligament, line of coalescence in the trunk and other places, and such matrices constitute *fetal rests* or *vestiges*. The same author shows that post-natal matrices may arise in the healing of a wound or ulcer, fistula, burns, etc. Portions of epithelium are separated, get placed deeply in the newly-forming tissue, become surrounded by connective tissue, and may later take on active growth. As Ribbert points out any fragment of isolated and imprisoned tissue may become a tumor.

Hereditation is extremely doubtful. S. W. Gross found hereditary influence by no means frequent in cancer of the breast. It is affirmed by some, denied by others, and doubted by a number. At most, hereditary influence may only predispose. Nevertheless, cases have occurred which cannot be explained by the term coincidence. In the celebrated "Middlesex Hospital case," a woman and five daughters had cancer of the left breast. A. Pearce Gould had charge of a woman for cancer of the left breast. The mother of this patient, the mother's two sisters, and two of the mother's cousins had died of cancer. Power reports a remarkable instance of family predisposition to cancer. A patient had his right breast removed for cancer in 1896. In 1897 cancerous glands were removed from the axilla. In 1898 he was seen again with an irremovable recurrent growth. His father died of cancer of the breast. He had two brothers, one of whom died of cancer

of the throat when sixty-five years of age, the other having died of cancer of the axilla when he was only twenty-four years old. Of his eight sisters, four died of cancer of the breast, and the two who are living both suffer from cancer of the breast. One sister died when an infant, and one died after giving birth to a child.* That there is such a thing as predisposition is rendered probable by the fact that out of many exposed under like conditions a single one may develop cancer.

Injury and inflammation may undoubtedly prove exciting causes. A blow is not infrequently followed by sarcoma; the irritation of a hot pipe-stem may excite cancer of the lip; the scratching of a jagged tooth may cause cancer of the tongue; chimney-sweeps' cancer arises from the irritation of dirt in the scrotal creases; and warts often arise from constant contact with acrid materials.

Physiological activity favors the development of sarcoma, and *physiological decline* favors the development of carcinoma.

Parasitic Influence.—Many believe that parasites cause cancer. This theory does not maintain that the tumor is the parasite, but that it contains the parasite, although Pfeiffer and Adamciewicz did at one time assert that a cancer-cell is not a body-cell, but a parasite resembling an epithelial cell. Some facts render a parasitic origin of malignant growths not improbable; as, for instance, the likeness of some tumors to infective granulomata, their occasional secondary development in distant parts of the body, the resemblance of the secondary to the primary growths, and the tenacity of their persistence. A parasitic origin of cancer is pointed to by its geographical distribution, the disease being very common in low and marshy districts, and Haviland ("Lancet," April 27, 1894) and others maintain that certain houses become infected, the disease appearing in these houses among successive families inhabiting them. They speak of such abodes as "*cancer-houses.*"

Some surgeons believe that cancer is contagious, but most observers deny it. Hanau found a rat suffering with cancer and inoculated other rats from it. Moreau in 1894 inoculated mice from a mouse with cancer. Guelliott, of Rheims, believes that cancer is primarily a local infection. He believes this because Moreau and Hanau have inoculated it from one animal to another of the same species, and if this can be brought about experimentally he sees no reason why it cannot happen accidentally. This surgeon says that cancer is very unequally distributed, that genuine cancer-centers and "cancer-houses" exist, and that numerous cases of accidental infection have occurred.† Hahn apparently succeeded in grafting cancer from one part to another on the same individual. Jensen and Borrell have inoculated the disease in white mice. Mayet, of Lyons, holds that cancer can be reproduced by grafting or by injection of cancer-fluid. Graf could not find "cancer-houses" after a careful search.‡ Geissler claims to have produced the disease in a dog by planting fragments of cancer in the subcutaneous tissue and vaginal tissue, but Czerny, Rosenbach, and others dispute the claim. Plimmer tells us that an epidemic of cancer arose among the captive white rats in the Frei-

* Brit. Med. Jour., July 16, 1898.
† Amer. Journal of Med. Sciences, June, 1895.
‡ Archiv f. klin. Chir., 1895, l., p. 144.

burg Pathological Institute and in each case the growth was on the rear part of the body. Roswell Park believes that Gaylord has really produced adeno-carcinoma in the lower animals. Hauser disputes the assertion that cancer must be an infectious disease because it is followed by secondary growths. Secondary growths in an infectious disease are caused by the bacterium; secondary growths in cancer are caused by the transference of cells of primary growth.* Hauser says with truth that the close connection between innocent and malignant growths renders the parasite view untenable, because to hold it we would be forced to believe that every tumor has a special parasite or that one parasite may cause many kinds of tumors.

There seems to be no doubt that autotransference of cancer can occur, although it rarely does so. Sippel has reported a case in which vaginal carcinoma developed at the point where the vagina was in contact with a pre-existing cancer of the portio.† Cornil has seen cancer transferred from one of the labia majora to the other, and from one lip to the other. Geissler was unable to transplant cancer, and Gratia also failed in his attempts. Duplay and Bazin say that transmissibility is possible, but only under conditions which are not practically realized. The facts that transplantation can be sometimes carried out, and that contagion is a possible occurrence under exceptional circumstances, do not prove that cancer is a parasitic disease, but simply prove that it can be transplanted. It is not that the cancer carries a parasite which will cause the disease in sound tissues, but rather that the cells of the cancer may themselves take root and grow in sound tissues. The parasitic theory arose from observation of the metastasis which occurs during the progress of the disease, and received support from the fact that inoculation of another part of an individual suffering from cancer may be followed by the development of a tumor like the original growth. For instance, if a cancer is growing upon the lower lip, the upper lip may be inoculated (*contact cancer*). The same it true of the labia. Mr. Harrison Cripps reported the occurrence of cancer of the skin of the arm from contact with an ulcerating scirrhus of the breast. It has also been pointed out that carcinoma is especially common in regions predisposed by their situation to injury and infection, and that, "among the lower animals at least, tumors resembling carcinomas have been transplanted from one to another" ("Recent Studies upon the Etiology of Carcinoma," by Joseph Sailer, "Phila. Med. Jour.," June 7, 1902). But there is great doubt as to the cancerous nature of some of the tumors which have been successfully transplanted from one animal to another.

In successful transplantations there is as yet no proof that epithelial cells were not transferred with the supposed parasites, and if they were transferred the success of the experiment does not prove that cancer is due to parasites, but simply proves again what we knew before—that epithelial cells can be transplanted. Many parasites have been regarded as causative by different observers. Bacteria, yeast-cells, and protozoa have been found by different experimenters. It is not thought that bacteria are causative. Yeasts are regarded as causative by some. It is certain that they may exist in cancer, but it is by no means certain that they cause the disease. They may be only

* Hauser, in Biolog. Centralbl., Oct. 1, 1895.
† Centralbl. f. Gynäk., No. 4, 1894.

a contamination. Gaylord and others regard the protozoa as causative, but this statement does not seem to be proved. Many of the supposed parasites of cancer have been shown to be cell-degenerations or contaminations. We are justified in concluding that the parasitic origin is not as yet proved, and we agree with the elder Senn that it is improbable.

Tillmanns elaborately discussed the subject of cancer in the Congress of 1895. His conclusions seem most sound and scientific. He says there is no evidence of a bacterial origin of cancer. The parasitic origin has not been proved, and protozoa have not certainly been found. Cancer can be transferred from one part to another of the same individual, or from one individual to another of the same species, but never to one of a different species. It is possible that cancer can spread by contagion; this is very rare, but can happen (as when penile cancer is followed by cervix cancer in a wife). Because it is sometimes possible to transfer cancer, this does not prove that the disease is parasitic or infectious; it simply shows that *tissue* has been successfully transplanted.

Cancer à deux is cancer developing in people who live together. Such cases suggest but do not prove contagion. Behla collected 19 cases and Guelliot 103 cases. *Conjugal cancer* is classified as cancer à deux. Conjugal cancer is probably due to irritation or implantation and not to microbic inoculation.

Actinomycosis, long thought to be a true tumor, is now known to arise from the ray-fungus. Some think that psorosperms cause cancer. There can be no doubt that changes in the liver which practically constitute a new growth can arise from the growth of a cell called by Darier the "psorosperm." A disease due to psorosperms is called a "psorospermosis." It is affirmed by some that molluscum contagiosum, follicular keratosis, cancer, and Paget's disease are due to psorosperms. Some claim to find the parasite in all cases of cancer, while others can find it in only 4 or 5 per cent. of the cases.

Heneage Gibbes affirms* that dilatation of the bile-ducts of a rabbit's liver is caused by the chronic irritation arising from multiplication of the coccidium oviforme in them, and not in the columnar cells of the bile-ducts, as has been stated; and, further, that the large majority of glandular cancers show nothing that can be considered parasitic, the suspicious appearances noted in some few cases being due to endogenous cell-formation. The coccidium oviforme is a genus of the sporozoa, class protozoa, the lowest division of the animal kingdom. To this case belong the monera and infusoria. (For a further discussion of this subject see page 331.)

Malignant and Innocent Tumors.—Malignant growths infiltrate the tissues as they grow; benign tumors only push the tissues away; hence malignant tumors are not thoroughly encapsuled, while innocent tumors are encapsuled. Malignant tumors grow rapidly; innocent tumors grow slowly. Malignant tumors become adherent to the skin and cause ulceration; innocent tumors rarely adhere and rarely cause ulceration. Many malignant tumors give rise to secondary growths in adjacent lymphatic glands (cancer, except in the esophagus and antrum of Highmore, always does so; sarcoma rarely causes them, unless the growth be melanotic or unless it arises from the testicle or tonsil). Innocent tumors never cause secondary lymphatic involvement;

* Am. Journal of Med. Sciences, July, 1893.

although the glands near the tumor may enlarge from accidental inflammatory complications. The malignant tumors, especially certain sarcomata and soft cancers, may be followed by secondary growths in distant parts and various structures (bones, viscera, brain, muscles, etc.); innocent tumors are not followed by these secondary reproductions, although multiple fatty tumors or multiple lymphomata may exist. Malignant tumors destroy the general health; innocent tumors do not unless by the accident of position. Malignant tumors tend to recur after removal; innocent tumors do not if operation was thorough. The special histological feature of a malignant growth is the possession by its cells of a power of reproduction which knows no limit, the cells of the tumor living among the body-cells like a parasite, and invading and destroying the body-cells.

Classification.—Tumors may be classified as follows:

I. Connective-tissue tumors (those derived from the mesoblast).

1. Innocent tumors, or those composed of mature connective tissue: *Lipomata*, or fatty tumors; *fibromata*, or fibrous tumors; *chondromata*, or cartilaginous tumors; *osteomata*, or bony tumors; *odontomata*, or tooth-tumors; *myxomata*, or mucous tumors; *myomata*, or muscle-tumors; *neuromata*, or tumors upon nerves; *gliomata*, or tumors composed of neuroglia; *angiomata*, or tumors formed of blood-vessels; *lymphangiomata*, or tumors formed of lymphatic vessels. The term *lymphoma*, meaning a tumor of a lymphatic gland, was formerly applied to hypertrophy and hyperplasia of a lymphatic gland, no matter whether caused by syphilis, tubercle, Hodgkin's disease, or any other morbid impression. The term has been largely abandoned except as expressing enlargement of a gland, and does not convey any suggestion as to the cause. It is doubtful if there is such a thing as a true lymphoma, understanding by the term a neoplasm arising from and composed of lymphoid cells and resembling lymphatic structure. In the described cases the possibility of infection as a cause has not been eliminated.
2. Malignant tumors, or those composed of embryonic connective tissue: *Sarcomata* and adrenal tumors.
   Endotheliomata are regarded by some as constituting an independent group and by others as a variety of sarcomata.

II. Epithelial tumors (those derived from the epiblast or hypoblast).

1. Innocent tumors, or those composed of mature epithelial tissue: *Adenomata*, or tumors whose type is a secreting gland; and *papillomata*, or tumors whose type is found in the papillæ of skin and mucous membranes.
2. Malignant tumors, or those composed of embryonic epithelial tissue: *Carcinomata*, or cancers.

III. Cystomata are cystic tumors, the cyst-wall of which are new growths and the contents of which are produced by the cells of the newly formed cyst-walls.

IV. Teratomata (tumors containing epiblastic, hypoblastic, and mesoblastic elements).

Innocent Connective-tissue Tumor.—These growths mimic or imitate some connective tissue or higher tissue of the mature and healthy organism.

Lipomata are congenital or acquired tumors composed of fat contained

in the cells of connective tissue, which cells are bound together by fibers. If the fibers are excessively abundant, the growth is spoken of as a *fibrofatty tumor.* A fatty tumor has a distinct capsule, tightly adherent to surrounding parts, but loosely attached to the tumor; hence enucleation is easy. Fibrous trabeculæ run from the capsule of a subcutaneous lipoma to the skin; hence movement of the integument over the tumor or of the tumor itself causes dimpling of the skin. An ordinary circumscribed lipoma is of doughy softness, is lobulated, of uniform consistence, and on being tapped imparts to the finger a tremor known as pseudofluctuation. A fatty tumor is mobile, although it may be attached to the skin at points by trabeculæ. Lipomata are most frequent in middle life, and their commonest situations are in the subcutaneous tissues, especially of the back or of the dorsal surfaces of the limbs; they usually occur singly, but may be multiple and sometimes symmetrical. Senn described the case of a woman who had a fatty tumor in each axilla. A lipoma may grow to an enormous size (in Rhodius's case the tumor weighed sixty pounds), and the growth may be progressive or may be at times stationary and at other times active. The skin over a fatty tumor sometimes atrophies or even ulcerates; the tumor itself may inflame or partly calcify. When a lipoma has once inflamed it becomes immovable. Subcutaneous lipoma of the palm of the hand or sole of the foot bears some resemblance clinically to a compound ganglion; it is apt to be congenital. Lipomata of the head and face are rare. In the subcutaneous tissues of the groins, neck, pubes, axillæ, or scrotum a mass of fat may form, unlimited by a capsule and known as a "diffuse lipoma" (Fig. 115). A diffuse lipoma may dip down among the muscles. Such masses attain large size. The typical diffuse lipoma is occasionally seen on the neck. It begins back of the mastoid process on one side or on both sides. When large, it completely surrounds the neck, a huge double chin forming in front, a great mass hanging on each side, and the posterior portion being divided into two halves by a median depression. A *nevolipoma* is a nevus with much fibrofatty tissue. A very vascular fatty tumor is called *lipoma telangiectodes.* If the tumor stroma contains large veins, the growth is called a *cavernous lipoma.* A tumor containing much blood can be diminished in size by pressure. Fatty tumors may arise in the subserous tissue, and when such a growth arises in either the femoral or inguinal canal or the linea alba it resembles an omental hernia and is spoken of as a *fat-hernia.* In the retro-peritoneal tissues enormous fibrofatty tumors occasionally grow, and these neoplasms tend to become sarcomatous. Lipomata may arise from beneath synovial membranes and will project into the joints,

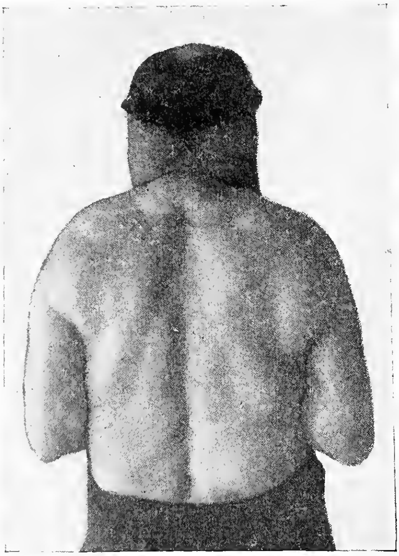


Fig. 115.—Diffuse lipoma.

being still covered by synovial membrane. Fatty tumors occasionally arise in submucous tissues, between or in muscles, from periosteum, and from the meninges of the spinal cord (J. Bland Sutton). A fatty tumor may undergo metamorphosis. The stroma may be attacked by a myxomatous process or a calcareous degeneration. The fat-cells themselves may become calcareous. Oil-cysts sometimes form. A *xanthoma* is a growth composed of fatty tissue in and about which there is marked infiltration with small cells. Such a tumor is flattened and slightly elevated. Several or many of these growths occur in the same person. The eyelids are the most common seat of xanthoma. The tumor may undergo involution or may become sarcomatous.

Diabetics are liable to develop xanthomata.

Treatment.—A single subcutaneous lipoma should be extirpated. The capsule must be incised, when the tumor can be torn out forcibly or can be

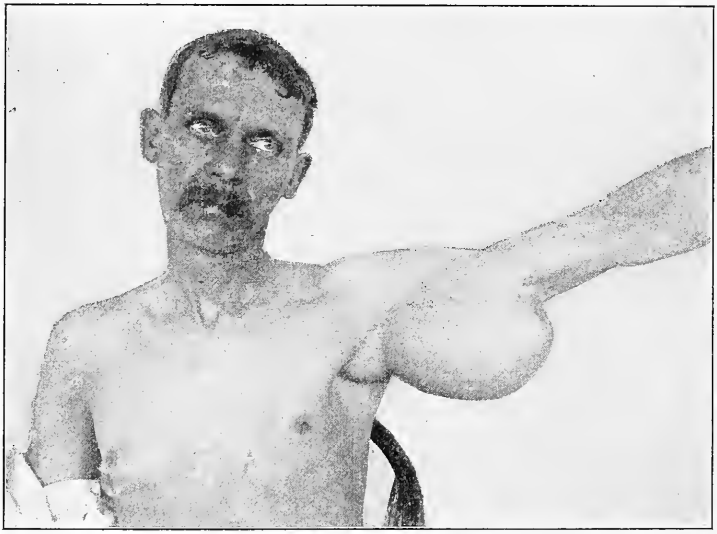


Fig. 116.—Fatty tumor.

enucleated by dissection; drainage is always employed for twenty-four hours, as butyric fermentation will be apt to occur, and necrosis of small particles of fat predisposes to infection. Multiple subcutaneous lipomata, if very numerous, should not be interfered with unless troublesome because of their size or situation, when the growth or growths causing trouble should be removed. It is difficult to extirpate entire a diffuse lipoma, and several operations may be needed to effect complete removal. Liquor potassæ, once recommended as possessing power, when taken internally, to limit the growth of multiple lipomata or diffuse lipoma, seems to be useless. Subperitoneal lipomata are rarely diagnosticated until the belly has been opened or the growth has been removed.

Fibromata are tumors composed of bundles of fibrous tissue. There are two forms, the hard and the soft. A *hard fibroma* consists of wavy fibrous bundles lying in close contact. Here and there connective-tissue corpuscles

exist between the fibers. A fibroma has no distinct capsule, though surrounding tissues are so compressed as to simulate a capsule. Fibromata are occasionally congenital, are most usual in young adults, but they may occur at any period of life, and in any part of the body containing connective tissue. Pure fibromata, which are rare, are generally solitary, grow slowly, are of uniform consistence, have not much circulation, and are hard and movable. Fibromata may form upon nerves, they may arise in the mammary gland, they may develop in the lobe of the ear, and they may spring from various fibrous membranes, from the periosteum of the base of the skull (*nasopharyngeal fibromata*), and from the gums (*fibrous epulides*). A *soft fibroma* contains much areolar tissue, the spaces of which are filled with fluid, so that the tissue seems edematous. Soft fibromata grow from the skin, mucous membranes, subcutaneous tissue, intermuscular planes, and periosteum. Soft fibromata are especially apt to arise from the skin of the scrotum, labia, inner surface of arm and thigh, and of the belly wall of a pregnant woman. They are not unusually multiple, grow slowly, but more rapidly than the hard fibromata, and may become quite large and possess distinct pedicles. Fibromata may become cystic, calcareous, osseous, colloidal, or sarcomatous, and may inflame, ulcerate, or even become gangrenous.

Fig. 117.—Keloid following a burn.

A *painful subcutaneous tubercle*, which is a form of fibroma commonest in females, arises in the subcutaneous cellular tissue, usually of the extremities. It is firm, very tender, movable, rarely larger than a pea, and the skin over it seems healthy. Violent pain occurs in paroxysms and radiates over a considerable area, of which the tubercle is the center. These paroxysms may occur only once in many days or many times in one day. Pain is always developed by pressure, and may be linked with spasm. Nerve-fibrillæ are now known to exist in these tubercles, a fact which was long denied.

A *mole* is a fibroma of the skin which is congenital or appears in the early weeks of life. It is rounded or flat, is usually pigmented and of a brown color, is slightly elevated above the cutaneous level, and has a few hairs or an abundant crop of hair growing from it, and varies in size from a pin's head to several inches in diameter, or may even occupy an extensive area of a limb or of the trunk. The tumor rarely grows after the thirteenth or fourteenth year. A mole may become malignant, melanotic carcinoma may arise from its epithelial structures, or melanotic sarcoma from its connective-tissue elements. A mole is an extremely vascular structure; it bleeds freely when cut or scratched, and it sometimes ulcerates. Occasionally several or many moles exist in the same individual. If a mole begins to increase rapidly in size, operation is imperative, as rapid growth probably indicates malignant change.

Fibrous epulis is a fibroma arising from the gums or periodontal membrane

(J. Bland Sutton) in connection with a carious tooth or retained snag; it is covered by mucous membrane, grows slowly, may attain a large size, and sometimes has a stem, but is more often sessile. It may undergo myxomatous change or may become sarcomatous.

Fibrous tumors may arise from the ovary, the intestine, and the larynx. Pure fibromata of the uterus are very rare, but fibromyomata are very common (see Myomata, page 310); hence the term "uterine fibroid" should be abandoned.

Molluscum fibrosum is an overgrowth of the fibrous tissue of both the skin and the subcutaneous structure. Senn excludes this form of growth from consideration with fibromata because of its supposed infective origin. It may be limited or widely extended; it may appear as an infinite number of nodules scattered over the entire body or as hanging folds of fibrous tissue in certain areas. *Keloid* (Fig. 117) is a fibroma of the true skin. It is a hard, fibrous, vascular growth, with a broad base, arising in scar-tissue; it is crossed by pink, white, or discolored ridges, and is named from a fancied likeness to the crab. It has rarely attacked mucous membrane. It is more common in negroes than in whites, and is most frequent in the cicatrices of burns, though it may arise in the scar of any injury, as the scar from piercing the ears, and in the scars of syphilitic lesions, tuberculous processes, smallpox, or vaccination. It is rare in early childhood and in old age. It grows slowly, lasts for many years, and may eventually undergo involution and disappear. It is almost useless to remove keloid by operation, as it will usually return, yet a study of the growth removed shows no reason for the inevitable return. The fibrous tissue of keloid springs from the outer walls of the blood-vessels (Warren). The papillæ of the skin above the tumor are destroyed or replaced by fibrous tissue.

Morphea, spontaneous or true keloid, is a name used to designate a growth of this description which does not arise from a scar; but it seems certain that scar-tissue was present, though possibly in small amount from trivial injury. The fact that keloid is especially common in the negro race (a race predisposed to tuberculosis) and that it is so frequently met with in the scars of known tuberculous processes, suggests the possibility of a tuberculous cause for the condition. The rapid return of keloid after operation suggests a near or distant infection which furnishes material to a point of least resistance which causes keloid to redevelop. Some cases of keloid have active tuberculous lesions, others have had them, in still others latent or distant lesions may be found by careful search. In many cases there is a family history of tuberculosis. I am at present investigating this important matter. It is certain that the keloid itself does not contain bacteria. Repeated examinations have failed to find them. It is quite possible that the growth contains toxins of tubercle bacilli, the toxins being the irritant cause. I am now seeking to determine if material from keloid introduced into tuberculous animals will cause a reaction, and if a reaction follows the injection of tuberculin into the victims of keloid.

Fibrous and papillomatous growths covered with endothelium may spring from any serous membrane. Such a growth of the choroid plexus calcifies

early and constitutes a *psammoma* or brain-sand tumor. Such tumors are met with not only in the choroid plexus, but also in the conarium and the dura. All psammomata are not fibrous; some are gliomatous and some are endotheliomatous. A *cholesteatoma* is a fibrous growth covered with endothelium and containing layers of crystalline fat. It occurs especially in the pia mater, but may arise in either of the other membranes or even in the brain substance, and is called a *pearl tumor*.

Treatment.—When in accessible regions fibromata should be enucleated. Fibromata should not be let alone, because any fibrous tumor may become a sarcoma. If a hard fibroma of the skin exists the skin is incised and the tumor is "shelled out." A soft fibroma is removed by an incision carried round the base of its pedicle. A painful subcutaneous tubercle should be excised. If a mole shows the slightest disposition to enlarge, or if it is subjected to pressure or irritation, it should be removed, because if allowed to remain it might develop into a malignant growth. It is often desirable to remove a hairy or pigmented mole, not only because it may become malignant, but also because it is unsightly. Fibrous epulis requires the cutting away of the entire mass, the removal of the related snag or carious tooth, and sometimes the biting away of a portion of the alveolus with rongeur forceps. A naso-pharyngeal fibrous polyp usually contains sarcomatous elements or becomes a spindle-cell sarcoma. If it has a pedicle, it may be removed by the cautery loop. In a severe case a part of the superior maxillary bone is removed by osteoplastic resection to permit of extirpation. Keloid should rarely be operated upon: it will only return, and will also recur in the stitch holes. Trust to time for involution, or use pressure with flexible collodion, by which method J. M. DaCosta cured a case following smallpox. It may be necessary to operate because of ulceration. If it is necessary to operate, remove the keloid and considerable adjacent tissue and fill the gap with Thiersch grafts. The administration of thyroid extract may be of benefit (a gr. v tablet three or four times a day). This drug must be given cautiously, as it may cause attacks characterized by fever, dyspnea, and rapid pulse. Thiosinamin hypodermatically has been used, it is claimed, with benefit. A 10 per cent. solution is made, and from 10 to 15 minims can be injected into the gluteal muscles every third day. I have seen two keloids cured by the use of the *x*-rays.

Chondromata (enchondromata) are tumors formed either of hyaline cartilage, of fibrocartilage, or of both. Chondromata are apt to arise from certain glands, the long bones, the pelvis, the rib cartilages, and the bones of the hands or feet, and often spring from unossified portions of epiphyseal cartilage. They may be single or multiple, and are most commonly met with in the young. They have distinct adherent capsules; they grow slowly, and if of osseous origin progressively hollow out the bones by pressure; they cause no pain; they impart a sensation of firmness to the touch, unless mucoid degeneration forms zones of softness or fluctuation; they are inelastic, smooth or nodular, immovable, and often ossify. A chondroma may grow to an enormous size. A chondroma of the parotid gland or testicle practically always contains sarcomatous elements, and any chondroma may become a sarcoma. Chondromata are notably frequent in persons who had rickets in early life. *Ecchondroses*, which are "small local overgrowths of cartilage" (J. Bland Sutton), arise from articular cartilages, especially of

the knee-joint, and from the cartilages of the larynx and nose. Loose or floating cartilages in the joints may be broken-off ecchondroses or portions of hyaline cartilage which are entirely loose or are held by a narrow stalk, and which arise by chondrification of villous processes of the synovial membrane; only one or vast numbers may exist; one joint may be involved, or several; they may produce no symptoms, but usually produce from time to time violent pain and immobility by acting as a joint-wedge. An ecchondroma may arise within the medullary canal of a long bone, from foci of dormant cartilage, and may lead to the development of a *solitary cyst* of large size by softening of the tumor. The femur is the most usual site of disease. It begins very insidiously and progresses gradually. There are slight lameness, trivial pain, tenderness below the level of the trochanter, apparent shortening and some bulging of bone. The bone may bend or at some spot may thin so that the cyst can be felt. Such a bone fractures from slight force, and after a fracture, when the effused blood and inflammatory exudate have been absorbed, a tumor can be distinctly detected. A solitary cyst of a long bone is apt to be regarded clinically as a sarcoma (Bergmann-Virchow).

Treatment.—Remove chondromata whenever possible, for, if allowed to remain undisturbed, they are apt to resent this hospitality by becoming sarcomatous. Incise the capsule and take away the growth, using chisels and gouges if necessary. Incomplete removal means inevitable recurrence. Amputation is very rarely demanded. Loose bodies in the joints, if productive of much annoyance, are to be removed, the joint being opened with the strictest antiseptic care. Amputation is sometimes performed for a solitary cyst of a long bone, the surgeon having looked upon the growth as sarcomatous. If a correct diagnosis is arrived at, an attempt should be made to remove the cyst without amputation. Bergmann succeeded in extirpating such a mass from the femur.

Osteomata.—Osteomata are tumors which are composed of osseous tissue. J. Bland Sutton says that osteomata are ossifying chondromata. Osteomata take origin from bone, cartilage, connective tissue, especially tissue near the bone, serous membrane, and certain glands and organs. Compact osteomata, which are identical in structure with the compact tissue of bone, arise from the frontal sinus, mastoid process, external auditory meatus, and other regions in those beyond middle life; they are small, smooth, round, densely hard, with small and occasionally cartilaginous bases.

Cancellous osteomata, which comprise the great majority of bone-tumors, are similar in structure to cancellous bone. They spring from, and are crusted with, cartilage; they may have fibrous capsules, and are often movable when recent, but soon become fixed; they have broad bases, are angled, nodular, firm (but not so hard as are the compact osteomata), painless except when pressed, occur particularly at the ends of long bones, may grow to large size, and are commonest in youth. Osteomata near joints become overlaid by bursæ, which in rare instances communicate with an adjacent joint.

The term *exostosis* has been used as being synonymous with osteoma, but wrongly so, as an exostosis is an irregular, local, bony growth which does not tend to progress without limit, and which is, hence, not a tumor. A true exostosis is seen in the ossification of a tendon-insertion, in a limited growth from one of the maxillary bones, and in a local growth from the last phalanx of the

big toe, which latter form of growth is known as a *subungual exostosis*. *Exostoses of the retrocalcaneal bursa* occasionally arise when this bursa is inflamed. Inflammation of this bursa is known as *Achillodynia* or *Albert's disease.* The bony masses sometimes found in the brain, lungs, testicle, various glands, and tumors are not true osteomata. Osteomata do not tend to become malignant and do not recur after removal.

Treatment.—Osteomata which are non-productive of pain or trouble do not demand removal. If they produce pain by pressure, if they press upon important structures, if they cause annoying deformities, or if they grow rapidly, then remove them by means of chisels, gouges, or the surgical engine. Subungual exostosis should always be removed. The nail should be split and part of it taken away, and the bony mass be gouged away or be cut off with forceps.

Odontomata * are tumors composed of tooth-tissue. They spring from the germs of teeth or from developing teeth. J. Bland Sutton divides them into (1) those springing from the follicle; (2) those springing from the papilla; and (3) those springing from the whole germ.

Epithelial odontomes, or **multilocular cystic tumors,** arise from the follicle, occur oftenest in the lower jaw, dilate the bone, have capsules, and are made up of masses of cysts which are filled with brown fluid. These cysts are met with most frequently before the age of twenty. *Follicular odontomes*, or *dentigerous cysts*, oftenest spring from the follicles of the permanent molars. In a dentigerous cyst there exists an expanded follicle which distends the bone, the follicle being filled with thick fluid and containing a portion of a tooth. A *fibrous odontome* is due to thickening of the tooth-sac, which prevents eruption of the tooth; fibrous odontomes are usually multiple, and are apt to occur in rickety children. A *cementome* is due to enlargement, thickening, and ossification of the capsule, the developing tooth being encased in cement. A *compound follicular odontome* is due to ossification of portions only of an enlarged and thickened capsule, and the tumor contains bits of cementum, portions of dentine, or small misshapen teeth. A *radicular odontome* springs from the papilla and arises after the crown of the tooth is formed and while the roots are forming; hence it contains dentine and cement, but no enamel. *Composite odontomes* are formed of irregular, shapeless masses of dentine, cement, and enamel. All the above forms occur in man. They present themselves as hard tumors associated with teeth or in an area where teeth have not erupted. Occasionally an odontome simulates necrosis; it is surrounded by pus, and a sinus forms.

Treatment.—The diagnosis is scarcely ever made until after an incision; hence, be in no haste to excise large portions of bone for a doubtful growth; incise first and see if it be an odontome, which requires only the removal of an implicated tooth, curetting with a sharp spoon and packing with iodoform gauze.

Myxomata are tumors composed of mucous tissue. They are rare as independent growths, although myxomatous change is frequent in the stroma of other tumors. The tissue type of these tumors is found in the vitreous humor of the eye and in the perivascular tissues of the umbilical cord (Whar-

* This section is abridged from J. Bland Sutton's striking chapter upon odontomes in his recent work on "Tumors."

ton's jelly). Bowlby states that myxomata are in reality soft fibromata whose intercellular substance has been replaced by mucin. The myxomatous state may be a stage in the formation of a fibroma, a stroma not having developed. Myxomata may result from myxomatous degeneration of cartilage, of muscle, or of fibrous tissue. These tumors are soft, elastic, usually pedunculated, tremulous, and vibratory. The stroma is very delicate and carries minute blood-vessels. Cutting into a myxoma causes a straw-colored, clear jelly to exude. Myxomata grow slowly, are encapsuled, have but little circulation, and the diagnosis may be impossible before removal of the growth. Some pathologists place myxomata among the malignant tumors, but most consider them as benign tumors, though they tend strongly to become sarcomatous (*myxosarcomata*). A sarcoma may undergo myxomatous degeneration.

Myxomata may arise from the skin; from the mucous membrane of the nose, the frontal sinus, the antrum, the womb, the auditory meatus, and the tympanum (*gelatinous polyps*); from the parotid and mammary glands; from the subcutaneous tissue, the nerve-sheaths, the intermuscular septa, the rectum, and the bladder (polyps). They may be congenital, but occur most often in young adults, as a result of inflammation. A sudden increase of growth indicates beginning malignancy (sarcomatous change). When a tumor begins to undergo myxomatous transformation we give to it a compound name; for instance, a chondroma undergoing myxomatous change is a chondromyxoma, a fibroma undergoing a like change is a fibromyxoma, etc. *Mucous polypi* grow from the mucous membrane of the nose, particularly from the outer wall near the middle turbinated bone, and often from the roof of the nares. Mucous polypi are soft and jelly-like, of a grayish color, and have stems or pedicles; they may be seen through the anterior nares, may project behind the veil of the palate, and may bulge out from the passages of the nose; they may be, and usually are, multiple; they may be present in one nasal fossa or in both; and they occur most commonly in youths and adults between the ages of fifteen and thirty-five years.

Hydatid moles of pregnancy are due to myxomatous changes in the chorion.

Treatment.—In treating myxomata, remove them promptly and thoroughly, because of the danger of sarcomatous change. Polyps of the bladder are removed by means of cutting forceps after suprapubic cystotomy has been performed. Nasal polyps may usually be twisted off or be removed by the wire snare or galvanocautery. Occasionally when the growths are numerous and recur rapidly after removal, the inferior turbinated bones should be removed with a saw (Rouge's operation). This operation secures ready access to the area of disease, which can be attacked radically. A very soft myxoma breaks up when removal is attempted, and the base must be cauterized.

Myomata are tumors composed of unstriped muscle-fiber mixed often with fibrous tissue. They are called *liomyomata*. Tumors composed of striated muscle-fiber and spindle-cells are known as *rhabdomyomata*. They are very rare and are always sarcomatous. Liomyomata are found in the womb, in the prostate gland, in the walls of the gullet, vagina, stomach, bladder, and bowel, in the broad ligament, ovary, and round ligament, in the scrotum, and in the skin. Myomata usually begin during or after middle age; they are encapsuled, they grow slowly, they are firm and hard, and produce annoyance by their size and weight or by obstructing a viscus or

channel. A liomyoma of the posterior portion of the middle of the prostate gland is known as a "middle lobe."

The so-called *uterine fibroid* is a myoma or fibromyoma. *Uterine myomata* may originate within the walls of the womb (intramural myomata), from the muscular structure of the mucous lining (submucous myomata), or from the muscular tissue of the serous covering (subserous myomata). Intramural uterine myomata may be single or multiple and may grow to an enormous size. Submucous myomata project into the cavity of the womb (fleshy polyps), and may project into the vagina. They distend the uterus and are often accompanied by menorrhagia or metrorrhagia. In some rare cases the projecting tumor is detached by Nature and the patient is cured; in some cases the myoma becomes gangrenous. A fleshy polyp may produce inversion of the fundus of the womb. Subserous uterine myomata cause trouble only by the inconvenience of weight or the discomfort of pressure. Uterine myomata are commonest in single women, and arise most frequently between the ages of twenty-five and forty-five. Negro women are especially prone to develop such tumors. They may never produce any symptoms. Some of these growths, by enlarging until they ascend above the pelvic brim, produce abdominal distention; some become jammed or impacted in the pelvis, and produce by pressure retention of urine, obstruction to the passage of feces or hydronephrosis. Impaction may occur temporarily at each menstrual period. Many myomata produce uterine hemorrhage; some cause retroversion of the womb; some protrude from the cervical canal; some are so large that they cause disastrous pressure upon the colon (obstruction), upon the iliac veins (great edema), or upon the ureters (hydronephrosis). Uterine myomata usually shrink after the menopause. Pregnancy in a myomatous womb usually ends in abortion. Uterine myomata may undergo fatty, calcareous, or myxomatous change, and may be infected by septic organisms as a result of the use of a uterine sound or of infection of the pedicle after oöphorectomy. Infection of a uterine myoma causes great enlargement, elevated temperature, sweats, and exhaustion.

The symptoms of myomata of the alimentary canal are similar to or identical with the symptoms of malignant growths. Myomata of the skin are rare growths; they are encapsuled, firm or elastic, and painless.

Treatment.—Cutaneous myomata are removed in the same manner as fibrous tumors. Uterine myomata are treated by rest and the administration of ergot, barium chlorid, and dilute sulphuric acid. If this treatment fails to arrest serious bleeding due to a flesh polyp, dilate the cervical canal and remove the growth. If there be dangerous bleeding in a woman who has some years to wait for the menopause and who has not a removable polyp as the cause, perform oöphorectomy in order to bring on an artificial menopause. When a myoma becomes impacted at each menstrual period, remove the ovaries and Fallopian tubes. Subserous myomata may be removed from the uterus after abdominal section, the resulting wound in the uterus being sutured. Hysterectomy is indicated for some very large tumors, for tumors that grow after the menopause, and for infected myomata. If the abdomen be opened to perform oöphorectomy, and the tubes and ovaries are found so implicated in the growth that they cannot be removed completely, or the broad ligament is found so drawn out that a safe pedicle cannot be secured, perform a hyster-

ectomy.* A recent suggestion for the shrinkage of uterine myomata is to ligate both the uterine and ovarian arteries. If a myoma of the prostate causes severe obstruction, perform a suprapubic cystotomy and remove the major portion of the enlarged gland; or make both a suprapubic and a perineal opening, push the gland into the perineum and shell it out with the finger, or make permanent suprapubic drainage.

Neuromata.—A *true neuroma* springs from nerve-tissue (brain, cord, or nerve-trunks); it is composed of medullated or non-medullated nerve-fibers which form a plexus or network, and which are not continuous with the fibers of the nerve-trunk or other area from which the tumor grows. True neuromata, which are rare growths, arise during middle life; they are small in size; are due to injury or hereditary tendency, and they may be single or multiple. There is usually around the tumor, rather than in it, severe neuralgic pain, which is greatly intensified by dampness, by blows, or by rough handling. The parts below a neuroma are cold, swollen, often anesthetic, and frequently present motor paralysis or trophic disorder. A *false neuroma* or *neurofibroma* is a fibrous tumor growing from a nerve-sheath, and is identical in structure with the sheath. False neuromata may be single, but they are often multiple; they may be as small as peas or as large as oranges; they are smooth and movable, and may cause great pain or may be painful only when pressed or struck; they may spring from roots, trunks, or branches, and they may be linked with the disease known as "*molluscum fibrosum.*" In *plexiform neuroma* some branches of a nerve enlarge and lengthen like an artery in a cirsoid aneurysm; the mass feels like beads or like a bag of worms; it is mobile, and no pain is felt on moving it; and it is generally congenital. In plexiform neuroma the nerve-sheath undergoes myxomatous change. *Malignant neuroma* is a primary sarcoma of a nerve-sheath, though any neuroma may become sarcomatous.

Traumatic neuromata are false neuromata and are occasionally well exhibited after nerve-section or amputation. On nerve-section the distal end shrinks and atrophies, the proximal end enlarges and becomes bulbous. A traumatic neuroma is composed of fibrous tissue which contains nerve-fibers. Such a growth is usually, but not always, painful on pressure or during dampness, and is most commonly seen in a stump which did not heal by first intention. In performing an amputation cut the nerves high up, and thus keep them out of the scar, permit them to remain mobile in their sheaths, and so prevent a tender stump. A tender stump may be due to anchoring of a nerve in a scar, the nerve ceasing to glide when the individual moves the extremity. The condition known as painful subcutaneous tubercle was discussed on page 305.

Treatment.—A false neuroma is to be removed, if possible, without destroying the nerve-trunk. If, in removing a neuroma, it is necessary to exsect a portion of a nerve-trunk, always endeavor to suture the ends of the divided nerve so as to facilitate restoration of function. For multiple neuromata—at least should the number be large or should molluscum fibrosum exist—surgery can do nothing. Plexiform neuromata may often be removed, but amputation may be required. Painful neuromata in stumps should be excised.

* See J. Bland Sutton's admirable article on "Uterine Myomata" in his work on "Tumors."

Gliomata.—These tumors develop from neuroglia and more often from the white substance than from the gray. They are usually single, and arise in the brain, rarely in the cord, and very rarely in the cranial nerves. They may take origin in one of the cerebral hemispheres, in the cerebellum, in the pons, or in the medulla. Some gliomata are soft and bear a close relationship to sarcoma; others are hard and resemble fibroma.

A glioma is a circumscribed growth in contrast to a gliosis, which is a widespread and unlimited hyperplasia of the neuroglia. Syringomyelia is due to gliosis of the spinal cord.

"A glioma consists of cells containing rounded or oval nuclei with very little protoplasm and fine protoplasmic extensions which interlace and form an intercellular reticulum" (Stengel).

A glioma passes almost insensibly into surrounding tissue, and there is no distinct edge; hence, because of the slight differentiation from brain substance, it may be overlooked during exploration. It is harder than the surrounding tissue; is vascular and of a pink or red color; and the normal shape of the part is often very little altered, although the tumor may reach the size of a lemon.

Hemorrhage may take place into a glioma, softening may occur, cavities may form, or the growth may become sarcomatous or psammomatous. The symptoms of a glioma of the brain depend on the situation.

Treatment.—When the growth can be localized it is justifiable in some cases to attempt its removal. Even a partial removal may be of benefit.

Angiomata or Hemangiomata.—An angioma is a tumor composed largely of dilated blood-vessels. The older surgeons called such growths *erectile tumors*. Some of the so-called angiomata are not genuine new growths, but are due to dilatation and elongation of blood-vessels.

Simple or capillary angiomata, nevi, or **"mother's marks,"** which affect the skin or subcutaneous tissue, are composed of enlarged and twisted capillaries and of anastomosing vessels surrounded by fat. These growths are congenital or appear in the first few weeks of life; they are flat and slightly raised, and are of a bright-pink color if composed chiefly of arterioles, and are bluish if composed mainly of venules; they are but little elevated; they can be almost completely emptied by pressure; they occasionally pass away spontaneously, but usually grow constantly and may become cavernous; they may ulcerate and occasion violent or fatal hemorrhage. One or several large vessels connect a nevus to adjacent blood-vessels. **Port-wine or claret stains** are pink or blue discolorations due to superficial nevi of the skin; they may be small in extent or they may involve a very large area, are not elevated, and do not usually spread. *Telangiectasis* is a form of nevus involving the skin and subcutaneous tissue in which many arterioles and venules exist. Simple angiomata are common on the forehead, the scalp, the face, the neck, the back, and the extremities. They may appear on the labia, the tongue, or the lips.

Cavernous angiomata, or **venous nevi** (Fig. 118), resemble in structure corpora cavernosa of the penis; there are large endothelial lined spaces with thin walls carrying blood, and there may be distinct vessels as well. Arteries send blood into the spaces, and veins receive it from the spaces. These channels and sinuses are enormously distended capillaries. Cavernous

angiomata arise in the skin and subcutaneous tissues; they are usually congenital, but may develop from simple angiomata; they are purple or blue in color; are more distinctly elevated than the capillary nevi; may be either cutaneous or subcutaneous; swell when the child cries, and are apt to pulsate; they may be emptied by pressure, and often look like cysts with very thin walls. Cavernous angiomata may arise in the breast, the tongue, the lip, the cheek, the gums, the subcutaneous tissues, or the muscles. If an angioma contains an excess of fat, the growth is called a "nevoid lipoma."

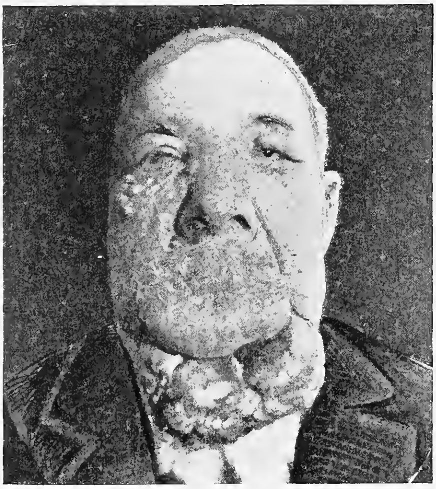


Fig. 118.—Cavernous angioma and lymphangioma.

Plexiform angiomata are known as "cirsoid aneurysms" or aneurysms by anastomosis (page 373).

Angiomata noticed soon after birth may disappear completely or may enlarge progressively.

Treatment.—These growths if large or growing must be treated. A capillary nevus can often be quickly cured by touching it with fuming nitric acid. A second application of acid may be required. The growth may be destroyed by heat—"a knitting-needle at a dull-red heat or the galvano-cautery" (Wharton). The application of ethylate of sodium or the employment of electrolysis will destroy the growth. Astringent injections are dangerous unless the base of the nevus is ligated, because they may lead to the formation of emboli.

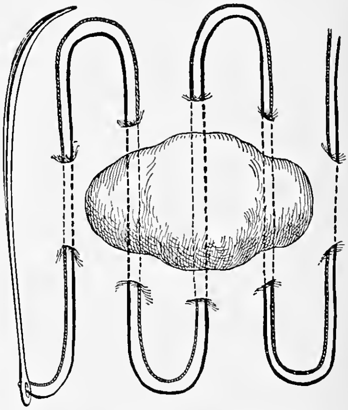


Fig. 119.—Method of applying Erichsen's ligature.

Small port-wine stains may be removed by electrolysis or multiple incisions, but extensive stains are ineffaceable. Small nevi may be ligated under harelip pins; larger nevi may be strangulated in sections by the Erichsen suture (Fig. 119), or may be completely excised. Excision is usually the best plan for the cure of angiomata. It is rapid, thorough, and leaves but a trivial scar. Excision should always be employed if we feel sure that the edges of the wound can be subsequently approximated and that there will not be a dangerous loss of blood. It is sometimes justifiable to excise an angioma even when approximation of the wound will obviously be impossible. In such a case the raw surface should be covered with Thiersch grafts.

Most superficial nevi and many cavernous angiomata can be treated by

excision. The incisions must be beyond the dilated vessels. In large angiomata involving the skin and also deeper parts, or involving a structure, like the lip, which it is undesirable to remove, electrolysis should be employed. The operation should be carried out with aseptic care, and, if the tumor is large, an anesthetic should be given.

The positive pole produces a firm and hard clot. One or more needles connected with the positive pole are inserted into the tumor, the needles being insulated to within about a quarter of an inch of their points. A flat moist pad is placed upon the skin near the tumor and is attached to the negative pole, and the pad is moved from time to time during the operation.

From twenty-five to seventy-five milliampères is the proper strength, and the current is passed for ten minutes. The current is increased for a moment before withdrawing the needles, otherwise they will stick to the tissue and cause bleeding when torn loose. After the withdrawal of the needles the nevus will be found to be hard, but the hardness will gradually disappear. It may be necessary to repeat the operation a number of times at intervals of ten days.*

Fig. 120.—Cavernous angioma, lymphangioma and lymphangiectasis, also beginning cancer.

Lymphangiomata are tumors composed of dilated lymph-vessels and are often, though not invariably, congenital (Fig. 120). A *lymphatic nevus* is a colorless or faintly pink elevation; if it is punctured with a needle, lymph flows from the puncture. One or several nevi may be present in the same individual. The dilatation is due to blocking of the lymph-channels. Local lymphangioma of the tongue is manifested by a cluster of papillary projections containing lymph. *Macroglossia* is a congenital enlargement of the anterior portion of the tongue, which enlargement grows more and more marked until finally the tongue is forced far out of the mouth. This condition of tongue enlargement is due to lymphangioma of the mucous membrane. *Lymph scrotum* is due to a similar growth. A collection of these warty-looking dilatations is called *lymphangiectasis*. Just as cavernous angiomata constitute a variety of blood-vessel tumors, so *cavernous lymphangiomata* constitute a variety of lymph-vessel tumors, and the spaces of the latter are filled with lymph instead of with blood. Areas affected with lymphangiectasis are liable to repeated attacks of erysipelas-like inflammation. Whether this inflammation is causative or secondary is not known. In tropical countries blocking of lymph-channels may be brought about by the filaria sanguinis hominis, a parasite which lurks in the lymph-vessels during the day and is found in the blood only at night. Lymphangiectasis is often the first stage of elephantiasis.

* Cheyne and Burghard's "Manual of Surgical Treatment."

Treatment.—A lymphatic nevus requires excision. In macroglossia the bulk of the mass should be removed by a V-shaped cut, the mucous membrane being sutured so as to cover the stump. In conditions due to the filaria, anilin-blue has been given internally.

Malignant Connective-tissue Tumors, or Sarcomata.—The sarcomata are composed of embryonic tissue-cells, the intercellular substance being very scanty and they *resemble* a process of chronic inflammation. They develop from connective tissue, rarely have a definite stroma, and the constituent cells, as a rule, proliferate with great rapidity. If a sarcoma has a stroma of connective tissue, this stroma contains lymphatics and such a sarcoma infects adjacent glands. In most cases there is no connective-tissue stroma and no lymphatics. In a sarcoma without a definite stroma the blood-vessels are not surrounded by lymph-spaces and are quickly invaded by cells (B. H. Buxton). The rapidly growing forms are very vascular, the blood flowing in vessels whose walls are very thin or running in canals lined by endothelium and bounded by sarcomatous cells. Such a tumor may pulsate and have a bruit, and hemorrhage often takes place into its substance. A rapidly-growing soft sarcoma with dusky skin above it (Fig. 122) may be mistaken for an abscess. A slow-growing sarcoma has but few vessels. Sarcoma tends strongly to infiltrate adjacent parts. The growth disseminates by means of the blood and the vessel-walls, particles of the tumor being carried by the venous blood to the heart and from this organ to the lungs, where they lodge and form secondary growths. Emboli from these secondary foci are sent out by the arterial blood to various portions of the body, as the bones, kidneys, brain, liver, etc. This process is known as "*metastasis.*" In some cases sarcoma is disseminated widely throughout the body, almost all the tissues showing minute white spots of secondary sarcoma which resemble tubercles. Such widespread dissemination is called *sarcomatosis.* Sarcoma follows the vein-walls for considerable distances and builds elongated masses of tumor-substance inside the veins. The tumor may possess a capsule when it is in an early stage, but soon loses this except in very slow-growing varieties or in mixed forms growing by central proliferation, but secondary sarcomata are often encapsuled. Sarcomata may arise at any age from birth to extreme senility, but they are commonest during youth and early middle age. They are not hereditary, and often follow traumatism and inflammation. A number of observers maintain that they are due to parasites (the question of the parasitic origin of malignant disease is discussed on page 299). A sarcoma may be primary or may arise from malignant change in an innocent connective-tissue growth (chondrosarcoma, fibrosarcoma, etc.). A sarcoma rarely affects adjacent lymphatic glands unless it

Fig. 121.—Sarcoma of the antrum.

Fig. 122.—Small round-celled fungating sarcoma of neck.

Fig. 123.—Small round-celled sarcoma of neck. Skin has given way and a bleeding mass is exposed.

contains lymphatics, and the great majority of sarcomata do not contain them. Occasionally sarcoma-cells are carried to adjacent glands by the vein-walls rather than by the lymph-stream. Sarcoma of the tonsil, sarcoma of the testicle, melanotic sarcoma, and lymphosarcoma do affect the glands. The skin over the tumor may give way, a bleeding fungus-mass protruding fungus hæmatodes) (Figs. 122, 123, and 124), and suppuration may cause septic enlargement of adjacent glands. After removal of a sarcoma the growth tends to recur, and the recurrent tumor may be either more or less malignant than its predecessor, the degree of malignancy being in direct ratio to the number and smallness of the cells. A sarcoma is malignant by local tissue-infection and by dissemination. Sarcomata rarely cause pain when they are not ulcerated. They are commonest in the skin and connective tissue of the extremities, but they arise also from bone, neuroglia, periosteum, the lymphatic glands, the breast, the testicle, the eyeball, the parotid, and other parts. Not unusually a pigmented mole becomes sarcomatous. Hemorrhages into a sarcoma often

Fig. 124.—Sarcoma of neck (Horwitz).

Fig. 125.—Dr. W. R. Bishop's case of small-celled sarcoma of the antrum.

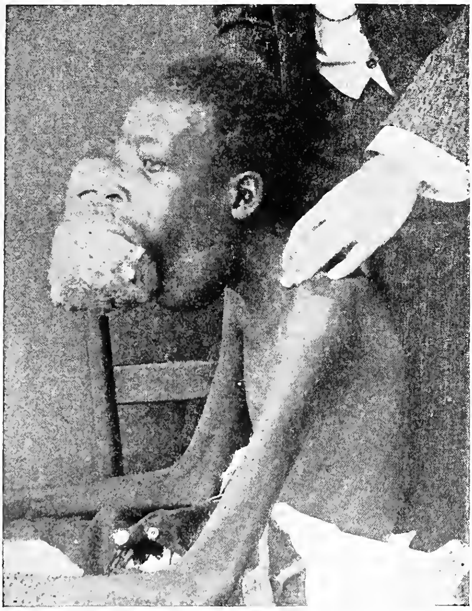


Fig. 126.—Dr. W. R. Bishop's case of small-celled sarcoma of the antrum.

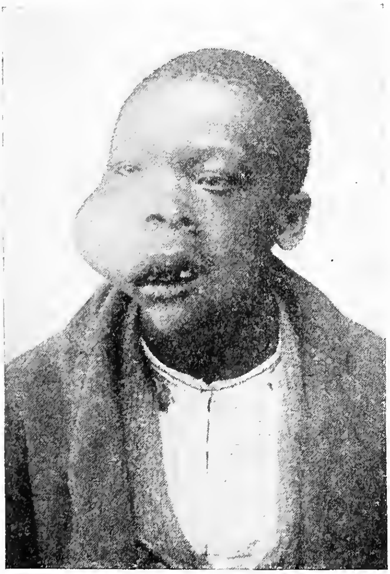


Fig. 127.—Osteosarcoma of eighteen months' standing of right side of superior maxilla. Note bony lump on left side of lower jaw.

occur, with the result of suddenly increasing the size of the mass and formation of blood-cysts. Sarcomata are subject to partial fatty degeneration, to myomatous changes which produce cavities filled with fluid, to calcification, and occasionally to necrosis of large masses.

Varieties of Sarcomata.—The following species of sarcomata are recognized:

1. *Round-celled sarcoma* is a tumor composed of round or spherical cells and resembling a chronic inflammatory area. The intercellular substance is scanty, the mass is soft and vascular, and grows with great rapidity. It often softens, and may become cystic. The cells may be small or large. The smaller the cells the more malignant the growth. A growth composed of small round cells is the most malignant form of sarcoma (Fig. 128). *Lymphosarcoma* is a form of round-celled sarcoma which arises from lymphatic glands, lymphoid tissues, the thymus gland, the spleen, and some other

Fig. 128.—Small round-celled sarcoma of the neck.

structures. The structure of a lymphosarcoma resembles the structure of a lymph-gland in the fact that it has a reticulum which looks like lymphadenoid structure. *Chloroma* is a form of lymphosarcoma arising particularly from the periosteum of the bones of the cranium and face. The cells contain greenish pigment, hence the name. What is known as *glioma* of the eyeball is not a true glioma, but is really a sarcoma composed of small round cells.

2. *Spindle-celled sarcoma* is a tumor composed of large or small spindle-shaped cells lying in a matrix, which may be homogeneous, but which may show some attempt at fiber-formation. Angular cells and stellate cells are often present. The cells may be placed in columns, which are at some places nearly parallel, and which at others diverge or interlace. Often there is no orderly arrangement. Spindle-celled sarcomata are usually harder than round-celled growths, but are sometimes quite soft. Cystic changes may occur. If there is a large amount of intercellular substance the growth is known

as a *fibrosarcoma.* A *rhabdomyoma* is really a spindle-celled sarcoma containing striated muscle-cells. The spindle-celled sarcomata often contain cartilage. Spindle-celled growths are by no means as malignant as round-celled tumors. Often they do not show any tendency to metastasis. The greater the amount of intercellular substance, and the fewer the cells, the less the malignancy. Spindle-celled growths constitute the majority of sarcomata met with in practice.

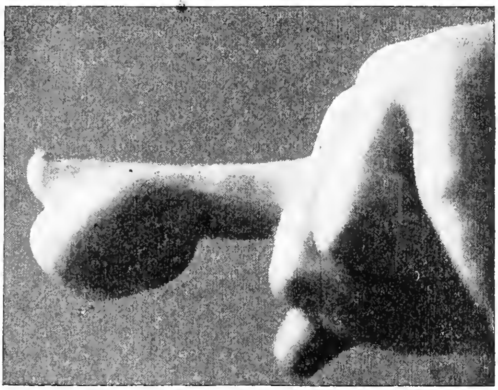


Fig. 129.—Spindle-celled sarcoma of sheath of flexor tendon of finger.

3. *Giant-celled* or *myeloid sarcoma* is characterized by the presence of very large cells, with many nuclei looking exactly like the myeloplaques of bone-marrow. The remainder of the growth is composed of spindle-cells, of round-cells, or of both spindle-cells and round-cells. Such a growth is maroon-colored on section. It arises most usually from bone, especially from the interior of a long bone, hence is often called *osteosarcoma.* It may, however, arise from other structures than bone. It is the

Fig. 130.—Melanotic sarcoma.

least malignant form of sarcoma. Metastases rarely occur, and the growth often admits of complete extirpation and cure. Some surgeons do not class these growths with sarcomata.

4. *Alveolar Sarcoma.*—Alveolar sarcoma is a tumor containing both round-cells and spindle-cells, and characterized by the formation of acini, filled with round-cells of large size resembling epithelioid cells. The walls of the acini are formed of spindle-cells and fibrous tissue, and in these trabeculi are the blood-vessels. The collection of the cells in the alveoli makes the structure resemble that of a cancer. Such growths are often pigmented. Alveolar sarcomata arise particularly from moles of the skin, but may arise from lymphatic glands, serous membranes, the testicle, and other parts. Such growths are very malignant.

5. *Melanotic or Black Sarcoma* (Fig. 130).—The color of such a tumor is due to pigment in the cells or matrix. These growths are usually composed of

Fig. 131.—Dr. Hansell's case of cystic myxosarcoma of the orbit.

round-cells, but may consist of spindle-cells, and they are sometimes alveolar. Melanotic sarcomata spring from parts which contain pigment (the skin and the choroid coat of the eye); they are apt to arise from pigmented moles; they are very malignant; they implicate related lymphatic glands, and during their existence the urine contains pigment.

6. *Hemorrhagic sarcoma* is a sarcoma containing blood-cysts which result from parenchymatous hemorrhages.

7. *Angiosarcoma* takes origin from the outer coat of a blood-vessel. The growth is often very vascular, and when the blood-vessels are notably dilated the tumor is called a *telangiectatic sarcoma.* The ordinary forms of angio-

sarcoma are only moderately malignant, but alveolar and melanotic forms occur which are highly malignant. Angiosarcoma may arise in the skin, in a serous membrane, and in a salivary gland.

8. *Cylindroma, or Plexiform Sarcoma.*—In this variety the cells adjacent to vessels have undergone hyaline or myxomatous degeneration; the cells distant from vessels are unchanged. Section shows the normal cells apparently contained in spaces with hyaline walls. These degenerative changes occur most often in the angiosarcomata. Cylindromata arise from the brain, salivary glands, lachrymal glands, and rarely from the subcutaneous tissue. The growths are only moderately malignant.*

9. *Mixed tumors* consist partly of mature and partly of embryonic tissue, the cellular elements exceeding the adult elements in amount. Among these mixed tumors are *fibrosarcoma* or the *recurrent fibroid tumor*, *myxosarcoma* (Fig. 131), *chondrosarcoma*, *gliosarcoma*, and *osteosarcoma*.

10. *Endotheliomata* are tumors springing from endothelium, and the name is retained no matter what change the growth ultimately undergoes. Many writers include under the term endothelioma *psammoma*, myxosarcoma, angiosarcoma, and plexiform sarcoma. Others consider endothelioma a special and characteristic form of sarcoma. Some would not consider it with the sarcomata at all. The growth may take origin from the "endothelium of the blood-vessels and of the perivascular lymph-spaces, of the lymph-vessels, and of the great serous cavities (peritoneum, pleura, meninges)."† The characteristic cell is the endothelial cell, usually known as the epithelioid cell. The structure of these tumors is very variable and depends upon the origin. Some tumors "recalling the original vascular network" ("American Text-Book of Pathology"), others being distinctly alveolar. Many pathologists consider a *psammoma* of the dura to be an endothelioma with a fibrous stroma. A psammoma contains calcareous particles. In appearance an endothelioma strongly resembles cancer, and such a growth is often spoken of as endothelial cancer. Such growths can arise in many different situations, but are particularly common in the peritoneum, pleural membrane, membranes of the brain, ovary, and testicle. I have removed an endothelioma of the tonsil, and also one of the mammary gland. The proliferating endothelial cells lie in lymph-spaces. Many endotheliomata grow rapidly, secondary growths form, and metastases are apt to pass to the serous membranes. Certain endotheliomata grow slowly, do not infiltrate adjacent structure, and do not produce secondary growths. In the brain and cord endothelioma may produce no symptoms for a long time. It is not as yet possible, clinically, to distinctly recognize endotheliomata from ordinary sarcomata.

11. *Mycosis fungoïdes* is a disease which resembles sarcoma in many particulars and may perhaps be a form of sarcoma. It attacks the skin and subcutaneous tissues. The skin at first becomes red and swollen; numerous nodules form; the nodules become distinct tumors, soften at their centers, and fungation occurs. Microscopically the tumor resembles a lymphadenoma. Mycosis fungoïdes is considered by some pathologists to be multiple cutaneous sarcoma.

Treatment of Sarcomata.—Remove a sarcoma at once if it is in an

* Stengel, "Text-Book of Pathology."
† "An American Text-Book of Pathology," edited by Hektoen and Riesman.

accessible spot. Never delay removal. Cut well clear of it. If affecting a part where amputation is impossible, the rapidly growing sarcomata will almost inevitably return, and the very malignant variety, if uninterfered with, may terminate life in six months; but even in such case operation postpones the evil day and renders it possible that death will occur from metastatic growth in an organ, and that the patient will escape the horrors of ulceration and hemorrhage from the original tumor. Slowly growing and hard tumors offer some prospects of cure. The mixed tumor (as a recurrent fibroid) may repeatedly recur, and yet the patient may be cured at last by a sixth, an

Fig. 132.—Central sarcoma of the fibula.

eighth, or a tenth operation. In a case of spindle-celled sarcoma of the breast the younger Gross performed 22 operations in the course of four years, and eleven years later the woman was well. In one case of recurrent fibroid of the neck, the younger Gross operated five times. Three years after his death I operated once, and two years later again. Nine years after the last operation she was alive and well. In sarcoma of a long bone amputation should, as a rule, be performed, though in some cases of giant-celled sarcoma of the radius, ulna, or fibula excision may be employed. Bloodgood has reported excellent results from excision in these cases. In sarcoma of either jaw-bone, excision; of the eye, enucleation; and of the testicle, castration, is demanded. Sarcoma

of the ovary in adults demands removal, but in children the operation is generally useless. Sarcoma of the kidney in adults calls for nephrectomy, but in children the operation is usually of little avail. In my experience, in the cases of sarcoma of the kidney which survived operation, the growth always appeared in the other kidney. In melanotic sarcoma remove the growth and adjacent lymph-glands, or in some cases amputate. Removal of a sarcoma when there is no hope of a cure is often justifiable to prolong life, to relieve the patient of a foul, offensive, bleeding mass, and to permit of an easier road to death by means of metastasis to an internal organ. In an inoperable case the ligation of the vessel of supply may do good. In sarcoma of the tonsil Dawbarn advises the extirpation of the external carotid artery and the ligation of its branches. The operation is performed first on the side of the tumor and in a week or so on the other side. I employed it in 5 cases with distinct but temporary benefit. Occasionally, though very rarely, suppuration cures a sarcoma. Wyeth, of New York, reported a case of sarcoma of the abdominal wall. It was found possible to remove only part of the growth; suppuration followed and the tumor disappeared, and ten years later had not returned. A study of statistics seems to indicate that more cases of sarcoma are cured after operation if the wound suppurates than if it remains aseptic, and it has been proposed to deliberately infect the wound with pus germs to lessen the danger of recurrence. This proceeding, however, is dangerous to life.

It has been observed that an attack of erysipelas occasionally greatly benefits a sarcoma, causing large masses of the growth to soften or to slough and exposing a granulating surface. Busch noticed this in 1866, but the fact had been observed in the seventeenth century. Interest was decidedly awakened by Billroth's case of sarcoma of the pharynx which was cured by an attack of facial erysipelas. It was suggested that in inoperable cases of sarcoma erysipelas might be established artificially. Fehleisen inoculated tumors with cultures of erysipelas. Lassar, in 1891, employed the toxins (cultures rendered sterile by heat and filtration). In 1892 Coley began his observations. The first plan was as follows: a bouillon culture was made of the streptococci; this culture was filtered through porcelain and an injection was given once a day into and about the sarcoma. The first dose was ♏x, and it was progressively increased. The effort was to cause a febrile reaction, and sometimes the injections lead to softening or suppuration. Coley's present method is as follows: make cultures of erysipelas cocci in cacao broth; after three weeks inoculate them with the bacillus prodigiosus, and cultivate the mixed growth for four weeks. The mixed cultures are maintained at a temperature of 136° F. until they become sterile. This sterile fluid contains the toxins. The dose is from 1 to 8 minims. If the fluid is injected remote from the tumor the initial dose should be 1 minim. If the fluid is injected into the tumor the initial dose is $\frac{1}{4}$ to $\frac{1}{2}$ a minim (Wm. B. Coley, in "Am. Jour. Med. Sciences," March, 1906). The dose should be gradually increased until a chill occurs in from one-half an hour to two hours after the injection, followed by a temperature of 101°–104° F. In some cases there is so much depression after reaction that injections are given every other day, but if safely possible, they should be given every day (Coley). The object is to obtain a reaction with each injection. The more vascular the tumor the more severe the reaction (Coley). If an area softens during treatment Coley advises us to open and

drain the softened area. If improvement is going to occur it usually begins in from one to four weeks. If there is no improvement within four weeks there will not probably be any. It seems definitely proved that cases are occasionally cured by Coley's fluid. Spindle-celled sarcomata are influenced most favorably. Round-celled sarcomata are very refractory and so are cancers. The method is not entirely free from danger. It seems of value in post-operative cases to prevent recurrence. For this purpose it is applied twice a week for several months. Emmerich and Scholl claim good results from the injection of erysipelas serum. A sheep is injected with cul-

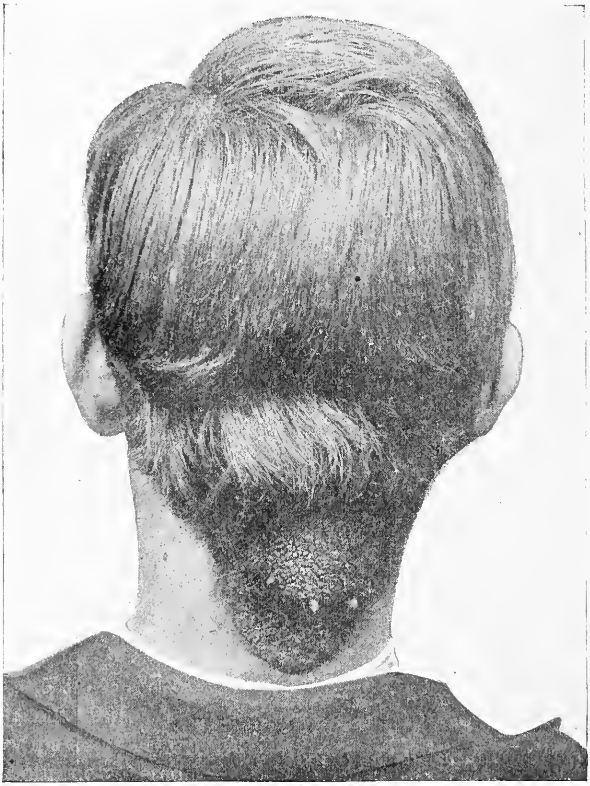


Fig. 133.—Keen's case of papilloma with angioma.

tures of erysipelas, the blood is drawn, the serum separated, filtered to remove cocci, and injected about the sarcoma. Results are not definite. Among other agents which have been used to inject inoperable sarcomata we may mention alcohol, chlorid of zinc, arsenic, corrosive sublimate, thiosinamin, pepsin, alkalies, etc. The injection of anilin products into the sarcoma, which has received a qualified commendation from some observers, has been abandoned by most surgeons. The x-rays are sometimes of benefit, but are not so serviceable as in carcinoma and possess a certain danger, for occasionally, after using them, dissemination rapidly occurs.

Adrenal Tumors.—Some of these tumors bear a strong resemblance

to adenomata and carcinomata. Some adrenal tumors are benign and among such tumors we note fatty growth, fibrous growth, and a growth resembling glioma. Another benign growth imitates the structure of the cortex of the adrenal. Malignant tumors occur, and many of them are identical or almost identical with sarcoma. One form is composed of epithelioid cells and resembles endothelioma.

Accessory adrenals are common. They are known as *adrenal rests*. "They are found oftenest in the connective tissue about the main adrenals, but also in the kidneys, the right lobe of the liver, along the renal vessels and spermatic veins, in the inguinal canals, and in the broad ligaments" ("American Text-Book of Pathology"). Tumors may take origin from adrenal rests.

Innocent Epithelial Tumors.—These growths imitate an epithelial tissue of the mature and healthy organism.

Papillomata, or Warts (Fig. 133).—Papillomata are formed upon the type of cutaneous and mucous papillæ. A papilloma consists of a fibrous stroma which contains blood-vessels and lymphatics and is covered with epithelium of the variety appertaining to the diseased part. Papillomata grow from the skin and from mucous membranes; they may be single or multiple; many may form in one region or various distant parts may be affected; they may be painless or may be ulcerated or bleeding; they vary in color from light pink to deep brown or black. Papillomata of the skin are usually hard; papillomata of mucous membranes are soft. A skin-wart may be smooth and rounded, or may look like a cauliflower, the epidermis upon it being very rough. A papilloma of a mucous membrane looks like a cauliflower. Papillomatous masses may gather around the anus, the vagina, or the penis during the existence of a filthy discharge (*venereal warts*) (Fig. 134), and crops of warts may appear on the hands of those who work in irritant material (as petroleum). Papillomata are apt to arise in mucous membranes about carcinomata or chronic ulcerations. A large crop of warts may disappear in a single night; hence the popular belief in the efficacy of charms. Warts are particularly common on the skin of the back of the hands and fingers, the skin of the back, and the skin of the neck and scalp. A single skin-wart may reach the size of a walnut and become pigmented. The squamous epithelium covering a skin-wart may become horny (*a wart-horn*). Other cutaneous horns arise from the nails, from the scars of burns, or from ruptured sebaceous cysts.

Villous papillomata grow chiefly from the bladder, but they may also grow from the stomach and intestine. A papilloma of mucous membrane covered with squamous epithelium looks like a wart of the skin. Papillomata of the larynx are formed of squamous epithelium. Villous papillomata form tufts like the villous processes of the chorion; they may be single or multiple, and may be sessile or pedunculated; they are very vascular, and are apt to bleed freely. Papillomata may arise in cysts of the paroöphoron, in cysts of the mammary gland, from the choroid plexuses of the ventricles of the brain, and from the spinal membranes. Papillomata may give rise to hemorrhage or may impair the function of a part. Any papilloma may become a cancer.

Treatment.—Venereal warts are treated by repeatedly washing with peroxid of hydrogen, drying with cotton, and dusting with a powder composed of borated talcum or of equal parts of calomel and subnitrate of bismuth, or of oxid of zinc and iodoform. If they do not soon dry up, cut them off with

scissors and burn with the Paquelin cautery. Ordinary warts may usually be destroyed in a short time by daily applications of lactic or chromic acid. In multiple warts of the face Kaposi applies daily for several days a portion of the following combination: sublimed sulphur, ʒv; glycerin, ʒiss; acetic acid, ℥iiss. Keeping a wart constantly moist with castor oil will usually cause it to drop off. Warts, and even extensive callosities, may be removed by painting once a day for five days with pure carbolic acid and covering with lint kept wet with boric acid. A convenient plan is to paint a wart daily with a solution containing 1 part of corrosive sublimate to 30 parts of collodion (hydrarg. chlor. corros., ʒss; collodion, ʒxv). Large warts should be excised. Villous papillomata of the bladder demand the performance of a suprapubic cystotomy in order to remove them. A papilloma of the larynx may be removed with the cautery loop or may be destroyed with the cautery.

Adenomata.—Adenomata are tumors corresponding in structure to

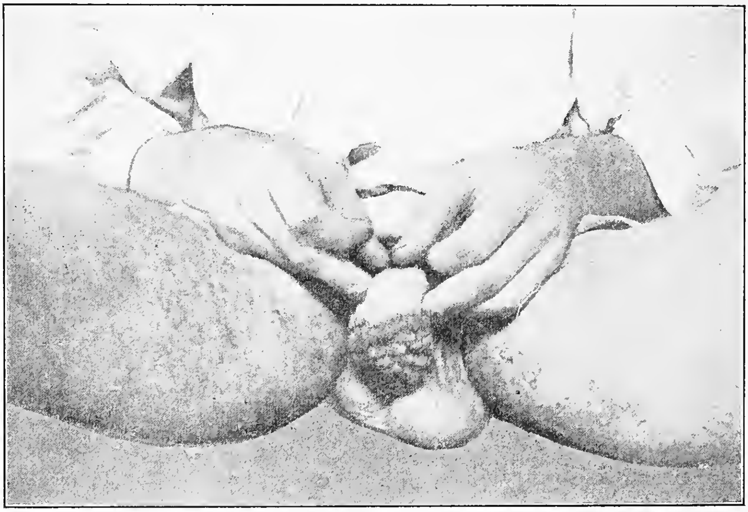


Fig. 134.—Venereal warts.

normal epithelial glands. They have a framework of vascular connective tissue, and they may contain acini and ducts like racemose glands or tubes like tubular glands. The acini or tubules contain epithelium of either the cylindrical or polyhedral variety. Adenomata grow from secreting glands, but cannot produce the secretion of the glands from which they spring; or, if they do secrete, the fluid is retained, and not discharged by the gland-ducts. Adenomata occur in the mammary gland, the parotid, the ovary, the thyroid gland, the liver, the sweat-glands, the sebaceous glands, the kidney, the pylorus, and the prostate; and they may spring as pedunculated growths from the mucous lining of the intestine and uterus. They are encapsuled, are usually single, but may be multiple, are of slow growth, but may attain a great size; they do not tend to recur after thorough removal, do not involve adjacent glands, and do not disseminate; they are firm to the touch; they tend to become cystic (especially in the thyroid gland), the fluid which dis-

tends the ducts being formed by mucoid liquefaction of the proliferating epithelium. If cysts form, the growth is spoken of as a *cystic adenoma*. If the framework of an adenoma contains considerable fibrous tissue, the tumor is named a *fibro-adenoma*. Adenomata are particularly liable to become carcinomatous.

In the breast a fibro-adenoma has a distinct capsule; it is elastic and movable, is usually superficial, and one occasionally exists in each gland. They are most common before the age of thirty, and are often painful, especially during menstruation. Cystic adenomata of the breast attain a large size; they are encapsuled and grow slowly, are most common after the thirtieth year, and are rarely painful. Both fibro-adenoma and cystic adenoma may arise in the male breast. Young unmarried women not unusually develop in the breast small, very tender, and painful bodies, most usually around the edge of the areola, which bodies increase in size and become more tender during menstruation; they are only cysts of the mammary tissue.

Adenomata of the thyroid gland usually begin before the fifteenth year. Adenomata may arise in the prostate if that gland be already the seat of senile hypertrophy. Adenomata of mucous glands may arise in the young or middle-aged. Adenomata of mucous membranes often cause hemorrhage and interfere with function.

Treatment.—Adenomata should be extirpated. To let them alone exposes the patient to the danger of cancerous change. By confusing adenomata of the mammary gland with small cysts of that structure an erroneous belief has arisen that the former, as well as the latter, may sometimes be cured by the local use of iodin, mercury, ichthyol, and the internal use of iodid of potassium. The treatment in the breast, as elsewhere, is excision.

Malignant Epithelial Tumors, Carcinomata, or Cancers.—Cancers are tumors taking origin from epithelial structures and composed of embryonic epithelial cells which are clustered in spaces, nests, or alveoli of fibrous tissue, and which proliferate enormously, extending beyond normal anatomical boundaries and as an invading host entering into connective tissue by way of the lymph-spaces. This unrestrained and unlimited reproduction of epithelial cells is the characteristic of cancer. The healthy epithelium has a strictly limited power of reproduction, as is illustrated by a skin-graft. Cancerous epithelium has an unlimited power of reproduction. The alveoli of cancer are distended lymph-spaces filled with proliferating cells. The cells of a cluster are not separated by any stroma, and the walls of the alveoli carry blood-vessels and lymphatics. The growth may be cancerous from the start, or may have begun, many think, as an innocent epithelial tumor. Cancers are always derived from epithelium (of glands, of skin, of mucous membrane, etc.), and if found in a non-epithelial tissue must be secondary, or must have arisen from a depot of embryonal epithelial cells of prenatal origin or from a dermoid cyst lying in the midst of a non-epithelial tissue, or epithelial cells must have been displaced so as to be among mesoblastic elements, by inflammation or injury. For instance, the bone does not normally contain epithelial cells. If osteomyelitis arises operation is performed and a lot of skin may be buried in the bone cavity or an epithelial graft may adhere. Such an epithelial area may become cancerous. Carcinomata have no capsules, rapidly infiltrate surrounding tissues, and are firmly anchored and immovable.

In the beginning a cancer is a local lesion; but it soon attacks adjacent tissue and related lymph-glands and by means of the lymph is carried to other structures, producing secondary tumors and diseases and enlargement of more distant lymph-glands. Finally lymph containing cancer-cells reaches the blood by the lymph-vessels and reaches distant parts and secondary tumors or metastatic deposits form. When lymphatic vessels are obstructed, lymph filled with cancer-cells may flow in a direction the reverse of that pursued in health. Widespread or general dissemination is due to carcinomatous thrombosis of a vein, or perforation of the wall of a vein, multiple emboli forming. Strange to say, emboli composed of cancer-cells may be surrounded with blood-corpuscles and move against the blood-current. A secondary growth (Fig. 135) consists of cells identical in character with and similar in arrangement to those of the parent growth. The cells of the secondary growth were transported from the primary growth and multiply in their new situation. For instance, the cells of a primary carcinoma of the liver may secrete bile, and the cells of a metastatic area may do the same. Fütterer has reported a case of carcinoma of the thyroid the pulmonary metastases of which secreted colloid. Stewart reported a case of cancer of the lungs and liver secondary to cancer of the pancreas. The secondary growths were of a structure similar to the pancreas and contained trypsin. Metastases from a columnar-celled rectal cancer are composed of columnar cells. Metastases from a squamous-celled epithelioma are composed of squamous cells. We often speak of lymph-glands enlarging when affected with cancer. The enlargement is there but is not due to the cells of the gland. It results from multiplication of the carcinoma cells deposited in the gland. As Henry Morris says ("The Bradshaw Lecture," "Lancet," Dec. 12, 1903), the parenchyma of the involved part does not undergo transition into cancer. After the growth of epithelium has lasted for a length of time the patient becomes poisoned by materials absorbed from the seat of disease (*cachexia*) and finally dies from cachexia and exhaustion or some complication. Cancer is rare before the age of forty although occasionally it is met with in younger persons. Cancer of the rectum is sometimes met with as early as the twenty-fourth year. I have operated on a woman of twenty-six for cancer of the breast. When xerodema pigmentosum exists in children cancer may arise in areas of the disease. If cancer appears in a young person growth is sure to be extremely rapid. A carcinoma is often the seat of pricking pain; the growth tends strongly to recur after removal; is prone to ulcerate, causing pain, hemorrhage, and cachexia; makes rapid progress, and is often fatal in from one to two and a half years. It is more common in women than in men, and rarely

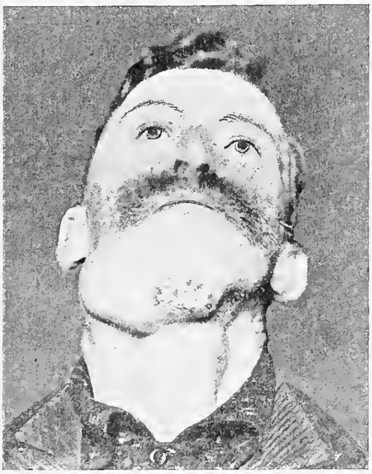


Fig. 135.—Secondary carcinoma of the submental and submaxillary lymphatic glands following carcinoma of the lip (Senn).

exists in association with tubercle. After a cancer has existed for a time in an important structure, or after a superficial cancer has ulcerated and become hemorrhagic, there are noted in the individual evidences of illness and exhaustion. We speak of this condition as the *cancerous cachexia*, and in it the muscles are wasted, the body-weight is constantly diminishing, the complexion is sallow, the face is sunken, pearly white conjunctivæ contrast strongly with the yellow skin, the pulse is weak and rapid, and night-sweats add to the exhaustion. The above condition is due to the absorption of toxic products from the diseased tissues, and also to pain, loss of sleep, bleeding, deprivation of exercise, and malassimilation of food. Mental depression is not a cause of recurrence, but is simply expressive of a condition of nutritive failure which may favor recurrence (J. D. Bryant). Recurrence after operation is due to the growth of cells which were not removed by the operation. Cancer may kill by obstructing a canal, by destroying the functions of a viscus organ, by hemorrhage, by anemia, by sepsis, or by exhaustion.


Fig. 136.—Epithelioma (Horwitz).

Cause of Carcinoma.—Heredity is discussed on page 298.

1. *Irritation.*—As Dennis says, clinical evidence points strongly to the view that inflammatory changes following irritation are responsible for cancer. Individuals with phimosis are particularly prone to cancer of the penis. Those who smoke a short-stemmed clay pipe, which grows hot when in use, are most liable to cancer of the lower lip. In the old days chimney-sweeps often developed cancer of the scrotum, which was always irritated by soot in the cutaneous folds. Cancer of the gall-bladder may arise if gall-stones exist. Cancer of the skin of the hands may arise in x-ray workers. Cancer of the skin may be induced by the influence of light (James Nevins Hyde, in "Am. Jour. Med. Sciences," Jan., 1906). The believers in the parasitic theory maintain that irritation and inflammation simply open the gates to the real cause.

In certain regions of the body, notably the tongue and lip, we regard prolonged chronic inflammation as very apt to eventuate in cancer and if it is not cured by ordinary means we advise operation. A condition persisting in spite of ordinary treatment, prone to eventuate in cancer but not as yet demonstrably cancerous, is called the *pre-cancerous* stage of cancer. It probably is already cancer although so early as to lack the positive signs.

Whereas chronic inflammation of epithelial structures is not infrequently followed by carcinoma, a single traumatism, as a blow, very seldom is. A woman with cancer of the breast is apt to lay the blame upon a blow but very seldom can the surgeon regard the blow as causal.

2. *The Inclusion Theory of Cohnheim.*—This theory was set forth on page 298.

3. *The Thiersch Hypothesis.*—This maintains that normal, healthy connective tissue has a restraining influence on the growth of adjacent epithelium; when connective tissue degenerates (as in advancing years or after prolonged irritation) its control over epithelium is weakened and the epithelium grows more rapidly than it does normally and if it invades the connective tissue cancer exists. This theory assumes that the connective tissue is a police force and the epithelial cells the criminal class, when the first is weakened or corrupted the second becomes active and uncontrolled.

4. *The Microbic Theory.*—Various agents have been described as causes, viz., bacteria, protozoa, and yeast fungi.

This theory was discussed on page 299. We do not regard it as proved, and even Plimmer, warm advocate as he is of the theory of contagion, admits that as yet there is no clearly demonstrated case of the transference of cancer from one man to another.

5. *The Biological Theory.*—In a unicellular organism the function of reproduction is, of course, possessed by the cell. In a multicellular organism certain cells are set apart for the performance of the function of reproduction, but all the cells possess the potentiality for reproduction but fail to exercise it. If cells undergo atavistic reversion they may again reproduce, and such unrestrained growth is cancer.

N. F. MacHardy ("Lancet," Oct. 24, 1903) points out that if a unicellular organism has not sufficient reproductive energy it fuses with another cell and is thus stimulated to produce numerous daughter-cells. In multicellular organisms cells may also fuse, take on active reproductive power, and produce hosts of new cells. When cells are persistently irritated, MacHardy points out that they become worn out by making repeated attempts at repair, undergo atavistic reversion, and actively resume the power of reproduction. According to this theory cancer is expressive of atavistic reversion of epithelial cells.

The Alleged Increase of Carcinoma.—Is cancer increasing? The apparent death-rate from cancer increases year by year. It is pointed out by W. Roger Williams that in England and Wales the mortality from cancer has increased from 1 to 5646 in 1840, to 1 to 1306 in 1896, and the proportion to deaths from other causes has risen from 1 to 129 in 1840, to 1 to 22 in 1896.* Roswell Park comments on the increasing number of deaths from cancer in New York State, and says if it continues for the next ten years the disease will kill more persons annually than phthisis, smallpox, and typhoid combined. Such statements are truly alarming, and yet the reality of this apparent increase is doubtful. A part of the apparent increase is due to the greater frequency of exploratory operations for diagnostic purposes, to the greater frequency of post-mortem examinations, and to more correct diagnoses of obscure internal conditions. Again, death certificates are filled in more accurately than was once the case. Neusholme says that just as deaths certified as due to old age grow apparently fewer every year, so other non-specific certifications grow fewer, and cancer gains as they lose. The experience of most practical surgeons is that there is a real increase in cancer, but the extent of the increase cannot be ascertained with any accuracy.

* Lancet, Aug. 20, 1898.

Classification of Carcinomata.—Carcinomata are classified as follows: (1) Epithelioma; (2) rodent ulcer, or Jacob's ulcer; (3) spheroidal-celled cancer; (*a*) scirrhous; (*b*) encephaloid; (*e*) colloid; and (4) cylindrical-celled cancer. Clinically we speak of *cuirass cancer*, a condition sometimes arising when the mammary gland is cancerous and due to the infiltration of the cutaneous lymphatics with cancer-cells; *chimney-sweeps' cancer* and *paraffin workers' cancer*, if either of these occupations seems to have been causative; *cancer à deux*, a phrase used in France to signify that carcinoma has occurred in two persons of a household who are not blood relations, but have been in close contact; *contact cancer*, when cancer appears in an area which was in close contact with a cancerous area in the same individual—for instance, when a cancer of the upper lip follows a malignant growth of the lower lip; when a carcinoma of the face follows a like growth of the hand; when a cancer appears on the penis of a husband whose wife has cancer of cervix uteri or vagina. A *melanotic carcinoma* is a form of encephaloid in which the cells contain melanin. Scirrhous cancer contains much fibrous tissue and is densely hard. An encephaloid is very soft or brain-like. *Marjolin's ulcer* is an epithelioma which arises from the epithelial edge of a chronic ulcer, a scar, or a sinus.

Epitheliomata.—An epithelioma arises from surface epithelium, and may arise from squamous cells or cylindrical cells, according to the location.

Squamous-celled epithelioma (Fig. 136) takes origin from the skin or from a mucous membrane covered with pavement epithelium. It is especially apt to appear at the junctions of skin and mucous membrane (as the lips) or the point of juxtaposition of different kinds of epithelium. Such a growth may arise in the anus or vagina; on the penis, scrotum, lips or tongue; in the mouth or nose; on the skin, and other situations. There is an ingrowth of surface epithelium into the subepithelial connective tissue, colonies of cells growing inward and forming epithelial nests. It may arise without discoverable cause, it may follow prolonged irritation, or it may arise in a wart or fissure. In the nipple it is not very unusually, and in the scrotum and nose it is occasionally, preceded by a persistent dermatitis due possibly to psorosperms, and known as *Paget's disease*. Paget's disease is not true eczema, but is rather malignant dermatitis. A crust gathers on the part, and beneath this crust is a raw, red, and moist surface, the edge of which is slightly elevated and somewhat indurated. In the beginning there is a strong resemblance to eczema. The nipple is apt to retract. The parts are the seat of a constant itching and scalding sensation. The area may become cancerous in a few weeks, but may not for years. Squamous epithelioma generally begins as a warty protuberance which soon ulcerates. A malignant or *true cancerous ulcer* (Fig. 136) has a hard, irregular base, uneven edges, a foul, fungus-like bottom, and gives off a sanious or ichorous discharge. This ulcer is the seat of sharp, pricking pain, sometimes bleeds, and extends over a considerable area, embracing and destroying every structure. Epithelioma usually affects lymphatic glands early, but such infection may be delayed for eight or ten months. Epitheliomatous glands break down in ulceration, making frightful gaps and often causing fatal hemorrhage. Dissemination is not nearly so common as in other forms of cancer, but it does sometimes occur.

Cylindrical-celled Epithelioma.—This form of growth takes origin from

structures covered with or containing cylindrical epithelium, and it contains cylindrical or columnar cells. It is composed of a stroma of fibers between which lie tubular glands lined with columnar epithelium and containing masses of epithelial cells. Such tumors are found in the uterus and gastro-intestinal tract, and may begin from the surface epithelium or from the cells of tubular glands. In these tumors there is an acinus-like structure and the spaces are filled with proliferating epithelium. Cylindrical-celled cancers also arise from the mammary gland, liver, and kidney. One of the most common seats of cylindrical cancer is the rectum. Cancer of the rectum may occur at an earlier age than cancer elsewhere, being not uncommon between the ages of twenty-eight and forty. Cylindrical-celled epitheliomata are at first covered with mucous membrane, but they soon ulcerate and involve the submucous and muscular coats in the growth. They grow rather slowly, usually, but not always, cause lymphatic involvement, and finally disseminate widely. They require in some regions from five to six years to cause death. In the rectum, however, growth is much more rapid and few victims of cylindrical-celled carcinoma of the rectum, if unoperated upon, live beyond 2 years and many of them die long before this period.

Fig. 137.—Rodent ulcer (Horwitz).

A *rodent* or *Jacob's ulcer, epithelioma exedens* or *cancroid* (Fig. 137), was called by the older surgeons "*noli me tangere*," because they found that surgical interference (incomplete removal as we now know) was sometimes followed by very active growth. A rodent ulcer is scarcely ever met with except upon the face though Jonathan Hutchinson saw one upon the forearm, and James Berry met with one upon the arm. It is especially common upon the nose and forehead. It begins after the age of forty as a little warty prominence which ulcerates in the center, the ulceration progressing at a rate equal to the new growth. The ulcer becomes deep; it is not crusted; its edges are irregular, hard, and everted; the floor is smooth and of a grayish color; the discharge is thin and acrid; and the parts about the sore contain numbers of visible vessels. Jacob's ulcer grows slowly, may last for years, does not involve the lymphatics, produces no constitutional cachexia, and is rarely fatal. In some cases, although growth is very slow, destruction eventually becomes very great because of ulceration, there is great loss of tissue and horrible deformity. A rodent ulcer is usually considered to be a malignant epithelial growth which springs from a sweat-gland, a sebaceous gland, or a hair-follicle, but Kanthack

asserts that before ulceration the rete and the sweat-glands are normal, but the sebaceous glands are destroyed. The base and edges of the ulcer are hard, which differentiates it from lupus; and, further, the bacilli of tubercle may sometimes be cultivated from the discharge of an area of lupus (page 230). Rodent ulcer begins below the skin, ordinary epithelioma begins in the skin, and a rodent ulcer contains no cell-nests. A rodent ulcer very rarely undergoes cicatrization, a fact which differentiates it from lupus. Occasionally, but very rarely, a small portion of the growth sloughs out and a temporary scar forms at this point.

Glandular Carcinoma.—Glandular carcinomata in structure resemble racemose glands. They consist of a stroma of connective tissue and alveoli filled with proliferating epithelial cells. If the proportion between the fibrous stroma and the cellular elements is about the same as in a normal gland, the growth is called simple. When the cellular element is in excess the growth is soft (medullary), and when the fibrous stroma is in excess the growth is hard (scirrhous).

1. *Scirrhous carcinoma* is a white and fibrous mass which has no capsule, which infiltrates tissues, and which draws in toward it, by the contraction of its outlying fibrous processes, adjacent soft parts, thus producing dimpling, or, as in the breast, retraction of the nipple. It is composed of spheroidal cells in alveoli formed of connective-tissue bands. The commonest seat of scirrhus is the female breast. It occurs also in the skin, vagina, rectum, prostate, uterus, stomach, and esophagus. It is most frequent in women after forty. It begins as a hard lump which is at first painless, but which after a time becomes the seat of an acute, localized, pricking pain. This lump grows and becomes irregular and adherent, causing puckering of the soft parts. After the skin or mucous membrane above it has become infiltrated ulceration takes place and a fungous mass protrudes which bleeds and suppurates. The adjacent lymphatic glands usually become cancerous, the time occupied being from six to ten weeks, and constitutional involvement is rapid and certain.

2. *Medullary* or *encephaloid carcinoma* is a soft gray or brain-like mass. It is a rare growth, it has no capsule, and it may appear in the kidney, liver, ovary, testicle, mammary gland, stomach, bladder, and maxillary antrum. An encephaloid cancer often contains cavities filled with blood, and this variety is known as a "hematoid" or a "telangiectatic" carcinoma. These growths are soft and semi-fluctuating, they infiltrate rapidly and soon fungate, and they terminate life in from a year to a year and a half. If the cells of encephaloid become filled with melanin, the condition is called "melanosis" or "melanotic cancer."

3. *Colloid cancer* is extremely rare. It arises from either a scirrhus or an encephaloid, when the cells or the stroma of such a growth undergo colloidal degeneration. On section there will be seen in the center of the growth a series of cavities filled with a material resembling honey or jelly; the periphery is frequently an ordinary scirrhus or encephaloid cancer. Colloid degeneration is most prone to attack carcinomata of the stomach, mammary gland, and intestine. The name colloid cancer is often given to glistening, gelatinous, malignant growths springing from the ovary, testicle, mammary gland, or gastro-intestinal tract. The condition is due to mucous degeneration of the

connective tissue or of the epithelial tissue of a carcinoma. Only a portion of the tumor may degenerate or the entire mass may become gelatinous.

Syncytioma Malignum.—By this name is meant a malignant epithelial growth arising from the site of the placenta during pregnancy or the puerperal state. It resembles placenta in appearance and rapidly causes metastases by way of the blood-vessels. It is quickly fatal.

Treatment.—Carcinomata demand early and free excision, with removal of implicated glands. Anatomically related lymph-nodes must be removed even if they show no evidence of involvement. If operation is early and thorough, and if certain regions are involved, a considerable proportion of cases can be cured. Carcinomata of the lip, the skin, and the mammary gland can often be cured. A recurrent growth may be removed as a palliative measure, to lessen pain and to relieve the patient from ulceration and hemorrhage, but such an operation is rarely curative. If a growth does not recur within five years after removal, a cure has probably been attained; in fact, if there is no recurrence within three years, the case is probably cured. The three-year limit has been usually accepted since Volkmann's paper on the subject. A rodent ulcer should be excised or else be curetted and cauterized with the hot iron or the Paquelin cautery. In cancer of the lower *lip*, remove the growth by Grant's operation (*q. v.*), or by a V-shaped incision, or cut away the entire lip. In every case remove the glands beneath the jaw. In cancer of the *tongue*, excise this organ and also the lymph-nodes from beneath the jaw and in the anterior carotid triangles. In cancer of the *breast*, remove the breast, the pectoral fascia, and the great pectoral muscle, and take away the fat and glands of the axilla. In cancer of the *rectum*, if near the surface, excise the rectum from below; if above five inches from the anus, do the sacral resection of Kraske and then remove the growth. In cancer of the *esophagus*, perform gastrostomy; in cancer of the *pylorus*, perform pylorectomy or gastro-enterostomy; in cancer of the *bowel*, do resection with end-to-end approximation, side-track the diseased area by an anastomosis, or make an artificial anus; in cancer of the *penis*, amputate and remove the glands of the groin. Erysipelas toxins and erysipelas serum have been tried in inoperable carcinoma, but without any positive benefit. Von Leyden and Blumenthal ("Deutsche medicinische Wochenschrift," Sept. 4, 1902) report benefit to human beings suffering from cancer by the injection of serum expressed from carcinomatous tumors. Such observations require many confirmatory studies before we can assume that a remedy has been found. The same is true of the employment of pyoktanin, thiosinamin, and of all other drugs that have been suggested. The *x*-rays are of distinct value in certain cases of carcinoma. Surface growths may be apparently cured, although unfortunately they are apt to return even after total disappearance. Deeper growths are apparently not benefited. In some cases ligation of the artery of supply or extirpation of the artery, as suggested by Dawbarn, notably retards growth. I have been able to confirm this statement. In cancer of the breast, oöphorectomy occasionally produces benefit or even cure (Beatson's operation). In inoperable cases palliative operations may be justifiable to relieve some urgent discomfort or get rid of a foul or bleeding mass. Gastro-enterostomy, gastrostomy, and colostomy are palliative operations. In a malignant growth of the nasopharynx tracheotomy may be

required, and in a malignant growth of the bladder it may be advisable to perform suprapubic cystotomy. In an inoperable case relieve the pain by opium, giving as much as may be required to secure ease. Opium so used seems not only to relieve pain, but to retard the growth of the tumor and to favor the development of fibrous tissue in the stroma.

Cystomata.—A cystoma is a benign cystic tumor in which the cells of the cyst-wall constitute the new growth. The cyst contents are derived from the cells of the wall. The tumor is the cyst-wall; the cells of this wall are derived from the epiblast, the hypoblast, or the mesoblast, and are either epithelial or endothelial. The cells of the cyst-wall adhere to connective tissue which seems to constitute a part of the wall. A thick wall contains much connective tissue, a thin wall very little. The nature of the contents is dependent on the character of the cells which constitute the tumor. Cysts lined by endothelium contain serous fluid; a cyst of the thyroid gland usually contains colloid material; a cyst lined by flat epithelial cells contains matter resulting from fatty degeneration, etc.

Cystomata may be congenital or acquired, and an acquired cystoma may arise after injury or follow inflammation. The cyst may increase in size progressively or its growth may be halted. The wall may become calcareous or even bony. When a cyst has one cavity, we call it monolocular; when there are several or many cavities, it is called multilocular.

Varieties of Cystomata.—The chief varieties are: Traumatic epithelial; atheromatous; mucous; mesoblastic.

Traumatic Epithelial Cystomata.—These growths have been called traumatic dermoids. Such a growth may arise after an injury which carries and deposits epithelial cells or a bit of skin deep into the connective tissue. For instance, a punctured wound of the hand may be followed by an epithelial cystoma. It may arise after a scalp wound or in the scar of a burn. The cyst grows only to a certain size and then remains stationary. It is lined by pavement epithelium and it contains products of the fatty degeneration of epithelial cells.

Treatment.—Extirpation of the wall.

Atheromatous Cystomata.—These growths, according to Senn, are met with particularly in the ovaries, in the orbital region, and at the base of the tongue, but they can arise almost anywhere. They may remain small or may attain a great size. Such a cystoma contains epithelial cells which have undergone fatty degeneration and sometimes contains oil. An atheromatous cystoma is deep seated and is not connected with the skin, in contrast to a sebaceous cyst, which is superficial and is a part of the skin. An atheromatous cystoma is lined with epithelium, but not with skin. A dermoid cyst is lined with skin or other definite structures. An atheroma is due to the displacement of a mass of epithelial cells, which mass was the matrix of the cystoma. "The displacement of the matrix of an atheroma occurred at a time prior to the differentiation of the epiblastic cells into the organs representing the appendages of the skin, while the matrix of a dermoid cyst points to a later displacement of the matrix" ("Pathology and Surgical Treatment of Tumors," by Nicholas Senn). Atheromatous cystomata may be congenital, but may not appear until puberty or even much later.

Treatment.—Extirpation of the wall of the cystoma.

Mucous Cystomata.—A mucous cystoma, like an atheromatous cystoma, is due to the displacement of epithelium, but in the former condition it is pavement epithelium and in the latter it is columnar epithelium. The one is filled with fatty débris and the other with a mucoid material. Such a mucous cystoma must not be confused with a retention-cyst of a mucous membrane. Mucous cystomata are found particularly about the lips, mouth, and pharynx. They rarely attain any considerable size. Cystomata lined with ciliated epithelium may arise in the testicle, the liver, and the brain.

Treatment.—Incise, cauterize, and drain. The wall is so delicate that excision is rarely possible.

Mesoblastic Cystomata.—They are lined with endothelial cells. They contain serous fluid, often grow to a large size, and sometimes disappear spontaneously. Mesoblastic cystomata are probably distended lymph-spaces. They are congenital and are most common in the neck, axilla, and perineum. In one case seen by the author such a cystoma of the neck appeared late in life, but it is probable that it had existed in childhood, and after disappearing for a long time had reappeared. The most common form of mesoblastic cyst is known as *hydrocele of the neck.*

Treatment.—Excision is very difficult. In one case in which I assisted Professor Keen it was successfully accomplished. The usual treatment is to tap frequently, after each tapping washing out with carbolic acid (2 to 5 per cent.), and applying pressure.

Cystomata of bone, of the thyroid gland, of the mammary gland, etc., are considered in the sections on Regional Surgery.

Teratomata.—The teratomata contain tissues or higher structures derived from two or all of the blastodermic layers. The tumors we previously considered are derived from only one of these layers. The elder Senn, in his work on "Tumors," thus defines a teratoma: "A teratoma is a tumor composed of various tissues, organs, or systems of organs which do not normally exist at the place where the tumor grows. The highest type of a teratoma is a fœtus in fœtu. In the simpler varieties the tumor is composed of heterotopic tissue, such as bone, teeth, skin, mucous membrane, etc. All teratoid tumors are congenital; that is, the tumor either exists at the time of birth or the patient is born with the essential tumor matrix. A teratoma never springs from a matrix of post-natal origin." Any human structure may be found in a teratoma. Various fetal malformations belong to this group, as do also double monsters, in which one of the embryos is rudimentary. The members of this group most often seen by the surgeon are *branchial cysts* and *dermoid cysts.*

Branchial Cysts.—When a branchial cleft fails to become completely obliterated, a branchial cyst may form. The branchial clefts are the analogues of the gill-slits of a fish. There are four of these clefts on each side of the neck. They are called clefts, but they are really grooves, and each groove on the skin has its counterpart in the mucous membrane of the pharynx. Each pharyngeal groove is covered with hypoblastic epithelium; each cutaneous groove is covered with epiblastic epithelium, and the two grooves are separated by mesoblastic structures. When the sides of a cleft do not unite and an opening forms in the mucous membrane, a *complete branchial fistula* results. When the sides of a cleft fail to unite, and, although the mucous

membrane is not perforated, the skin does not cover the cleft, an *incomplete branchial fistula* results. When the sides of a cleft toward the pharynx fail to coalesce, a *pharyngeal diverticulum* is produced. When the pharyngeal surface and the cutaneous surface both close, but the deeper part of a cleft remains open and epithelial cells are caught in mesoblastic elements, a *branchial cyst* is formed.

The essential cellular element of such a cyst is epithelium, either from the skin or pharynx; hence the branchial cyst is not a dermoid, because its histological elements are derived from only one of the blastodermic layers. Branchial cysts are most common in the triangle of election of the left side. They are round, smooth, often fluctuating, and are very deeply situated, being in close relation with the great vessels. Some cysts contain mucus, others serous fluid, others fatty débris.

Treatment.—In old children and in adults it may be possible to extirpate, although this is very difficult and often impossible. Other methods employed are incision, cauterization with the Paquelin cautery, and packing with gauze;

Fig. 138.—Traumatic dermoid cyst.

frequent tapping and injection with iodin; incision and drainage, every antiseptic care being observed. In all young children and in some older persons with deep cysts, the latter plan is the only one advised, and it will often fail, but will sometimes produce a cure.

Dermoid Cysts.—These cysts were first studied and described by Lebert. The name dermoid implies that the cyst contains skin, and it does contain skin or mucous membrane, the chief mass of the tumor being derived from proliferation of the cells of a portion of displaced epiblast or hypoblast. A superficial dermoid is formed by the inclusion in mesoblastic tissues of a portion of the epidermis or mucous membrane. Superficial non-traumatic dermoids are situated in the region of fetal fissures which have closed. A deep dermoid is formed from a collection of epithelial cells completely separated from the epiblastic tissue from which they originated. When a cyst originates from epiblastic cells so immature that the skin appendages have not as yet been formed it will contain only atheromatous material like that

found in a sebaceous cyst. When a cyst arises from epiblastic cells after they have so matured that the appendages of the skin have been formed, it will contain atheromatous matter, sweat, sebaceous matter, and hair. The first form is known as an *atheromatous cystoma;* the second, as a dermoid. A deep-seated dermoid may contain also such structures as prove it must have taken origin from "a displaced matrix representing different tissues and organs" (Senn). Such a dermoid may contain portions of organs, bone, cartilage, and teeth.

Dermoid cysts are most commonly found in the ovary and in regions where, during bodily development, the blastodermic layers come in contact; for instance, in the neck, the eyelids, the orbital angles, the region of the coccyx, the root of the nose, and the floor of the mouth. Such cysts are also found in the ovary, testicle, brain, eye, mediastinum, lung, omentum, mesentery, and carotid sheath. A dermoid cyst may be defined as a heterotopic cyst, the wall of which is composed of connective tissue lined with epithelium, and containing material formed by the proliferation of epithelium and often hair, teeth, or even bone. An injury may displace a bit of epithelium and lodge it in connective tissue and from this a traumatic dermoid may arise (Fig. 138).

Sarcoma may form from the connective-tissue elements of the wall of a dermoid cyst. A dermoid cyst may become cancerous, or innocent epithelial tumors may originate from the cyst lining. The epithelial cells may become fatty, and an oil-cyst may actually form. If the cyst epithelium was derived from mucous membrane, mucus may gather in the sac. A dermoid cyst may inflame or even suppurate. A dermoid cyst is free from pain unless it suppurates, inflames, or develops into a malignant tumor; it grows slowly and rarely attains any considerable size unless it arises in the ovary. Such cysts tend to appear in particular regions. A subcutaneous dermoid may or may not fluctuate. It is not in the skin as is a sebaceous cyst, but the skin can be moved over it. A sebaceous cyst moves with the skin. Subcutaneous dermoids about the orbit are adherent to the underlying periosteum. A sacral dermoid bears a striking likeness to a spina bifida. The matrix of a true dermoid is congenital, but the cyst often does not appear until puberty or later.

Treatment.—Complete extirpation. If any of the epithelium of the cyst-wall is left, the cyst will re-form. A superficial dermoid is removed in the same manner as a sebaceous cyst, and if it is adherent to underlying periosteum the portion of this membrane to which it adheres is also removed. A deep dermoid is removed as a tumor would be if operation is feasible.

Cysts.—A cyst is a cavity, abnormal or pathological in character, lined by a membrane and containing material usually fluid or semi-fluid. It is necessary to bear in mind the distinction between a cystoma and a cyst. Hektoen and Riesman, in "American Text-Book of Pathology," insist on this distinction. They say: "A *cystoma* is a true tumor, arising from active proliferation of a matrix destined to form cystic spaces; whereas a cyst is a secondary formation not primarily due to tissue proliferation." Cysts are divided into the following classes: Retention-cysts; cysts from softening; tubulo-cysts; and parasitic cysts ("American Text-Book of Pathology").

Retention-cysts.—A retention-cyst is formed by blocking of the duct of a gland or by failure in the absorption of the proper amount of the secretion of a ductless gland. A few characteristic forms of retention-cysts will be described.

Sebaceous Cysts.—These arise when the excretory duct of a sebaceous gland is blocked by dirt or occluded by inflammation. The orifice of the duct is often visible as a black speck over the center of the cyst. They are very common in the scalp, being known as *wens*, and upon the face, neck, shoulders, and back. Arising in the skin, and not under it, the skin cannot be freely moved over a sebaceous cyst. A sebaceous cyst is lined with epithelium and is filled with foul-smelling sebaceous material. A sebaceous cyst may suppurate. When a cyst ruptures and the contents become hard, a *horn* is formed. Another form of horn has been previously alluded to as due to horny transformation of a wart.

Fig. 139.—Multiple sebaceous tumors of the scrotum (Horwitz).

Treatment.—To treat a sebaceous cyst, incise the portion of skin above it, and dissect the sac entirely away with scissors or a dissector, trying not to rupture the delicate wall. If even a small particle of the wall is left, the cyst will re-form. If it ruptures during removal and it is feared that some portion may remain, paint the interior of the wound with pure carbolic acid. If acid is not used, close without drainage; but if acid is used, drain for twenty-four hours. If an abscess forms in a sebaceous cyst, open it, grasp the edges of the cyst-lining with forceps, dissect out this lining with scissors curved on the flat, cauterize with pure carbolic acid, and drain for twenty-four hours.

Mucous Cysts.—A mucous cyst is due to the blocking of a mucous gland or a mucous crypt. Mucous cysts occur particularly in the mucous membrane of the mouth and genito-urinary organs, and are filled with thick, adhesive mucus containing numerous epithelial cells. Such a cyst is of spherical outline, and the epithelial membrane which lines it is strongly adherent to tissues beyond.

Treatment: Incision, curetment, cauterization with pure carbolic acid, and packing or extirpation of a considerable part of the cyst, and curetment and cauterization of the part remaining.

Oil Cysts.—An oil cyst is due to fatty degeneration of epithelium lining a sebaceous cyst, or a milk cyst of the breast. As previously noted, a dermoid may result in an oil cyst.

Treatment: Extirpation, as for sebaceous cysts.

Salivary Cysts.—A retention-cyst of a salivary gland is known as a *ranula* (*q. v.*). These cysts are most common in the submaxillary or sublingual gland.

Lacteal or Milk Cysts.—Such a cyst occasionally arises in the mammary

gland during lactation, and is the result of blocking of a lactiferous duct (see Cysts of Mammary Gland).

Among other forms of retention-cysts, most of which are discussed in special sections of this book, we mention *hydrosalpinx*, a cyst due to blocking of a Fallopian tube; cysts due to obstruction of the bile-ducts (the most common form is known as *hydrops*, which is a dilated gall-bladder the result of obstruction); cyst of the thyroid gland; cyst of the pancreas; and *hydronephrosis*, a condition produced by obstruction of the ureter.

Cysts from Softening.—These cysts are formed by the disintegration of degenerated tissues. For instance, after a hemorrhage into the brain, softening may follow and a cyst arise. Cystic changes of this sort are frequently observed in sarcomata and carcinomata. A cyst from softening has a wall of connective tissue, but there is no endothelial or epithelial layer.

Tubulo-cysts.—This name was given by J. Bland Sutton to cysts formed in certain remains of embryonal ducts, which vestiges in the developed body ought to have been destroyed. A small cavity is left unobliterated, and in this space fluid gathers. The source of the fluid is usually the lining cells of the cavity. Branchial cysts are frequently considered under this heading. Two of the commoner tubulo-cysts are cysts of the vitello-intestinal duct and cysts of the urachus.

Cysts of the Vitello-intestinal Duct.—Such a cyst presents itself as a small, bright red, globular mass, which appears to arise from the umbilicus of a baby or a young child, and which usually has a distinct pedicle, but may be sessile. A cyst of this character forms when the vitello-intestinal duct atrophies from the gut toward the umbilicus, but a remnant at the umbilicus escapes obliteration, and from this remnant a cyst forms. The wall of such a cyst contains unstriped muscular fiber and is lined with mucous membrane. Occasionally the duct in the process of involution is not destroyed,—its caliber is simply lessened,—and the duct remains open in the navel and feces come from it. If the duct fails of obliteration at the intestinal end, a diverticulum remains at this point (Meckel's diverticulum).

Treatment.—A pedunculated cyst at the navel is treated by ligating its base and cutting the stalk beyond the ligature. A cyst with a thick base is dissected out. The surgeon must be careful to avoid confounding an umbilical hernia with a cyst of the navel.

Urachal Cysts.—The urachus is the obliterated allantois and is a cord running from the summit of the bladder to the umbilicus. This structure is in the middle line of the abdomen and in front of the peritoneum. A portion of the allantois may not be obliterated at birth, and in consequence of this failure a cyst forms. It grows to a considerable size, may push the peritoneum away and reach the pelvis, may communicate with the bladder, may break through the umbilicus or grow backward toward the spine.

Treatment.—Extirpation of the lining membrane, partial closure of the cavity by suture, and packing the unobliterated part.

Parasitic Cysts.—Parasitic cysts are due to the development of certain parasites in the tissues. The form most often encountered is known as hydatid disease.

Hydatid cysts are especially common in Iceland, and are frequent in Australia and South America, but are very rare in the United States. In the

United States 91 per cent. of cases occur in foreigners (Lyon). Hydatid cysts are due to echinococci. The adult echinococcus is the tapeworm of the dog (tænia echinococcus), and its ova or larvæ gain access to man's body by accompanying the food he eats and passing into the alimentary canal, from which situation they are transported to various organs by the blood. Osler says the embryo (which has six hooklets) burrows through the wall of the bowel and enters the peritoneal cavity or muscles; it may enter the portal vessels and reach the liver, or may enter the systemic circulation and pass to distant parts. The danger depends on two factors: "the situation and the liability of the cyst to suppurate" (Sidney Coupland). The organs most usually attacked are the liver and lung. In 60 per cent. of cases the liver suffers, and in 12 per cent. the lung (Thomas). Lyon estimates that the liver is the seat of disease in 73 per cent. of cases. Cysts sometimes arise in the intestine, genito-urinary passages, brain, or spinal canal. When the embryo lodges, the hooklets disappear and a cyst is formed. This cyst is composed of two layers, an outer capsule (cuticular membrane) and an inner layer (endocyst). The cyst contains clear saline fluid. As the cyst grows, daughter-cysts bud out from the wall of the mother-cysts, the structure of the daughter-cysts being identical with that of the mother-cysts. From the lining membrane of all the cysts, after a time, growths arise known as scolices, which represent the head of the echinococcus and exhibit four sucking disks and a row of hooklets (Osler).

The fluid is not albuminous, is occasionally saccharine, is thin and clear, and may contain scolices or hooklets.

A hydatid cyst may calcify, may rupture, or may suppurate. These cysts are very firm, but usually fluctuate. Palpation with one hand while percussion is practised with the other gives a persistent tremor (*hydatid fremitus*). If the cyst can be safely reached, some fluid should be drawn and examined for diagnostic purposes. When a cyst suppurates, positive constitutional and local symptoms arise. Hydatid cysts of the brain and cord tend to produce death in the same manner as do tumors. A cyst of the liver may rupture into the pleural sac, into the belly cavity, into the stomach, or into the bowel, producing shock, hemorrhage, and probably death. In rare cases hydatid cysts rupture into the pericardium or into a great abdominal blood-vessel, or externally. Rupture into the bile-passages is usually followed by suppuration of the cyst. Suppuration of a cyst may follow uncleanly tapping. It has been recently pointed out that eosinophilia is noted in most persons suffering from hydatid disease.

Treatment: An unruptured hydatid cyst of a superficial structure should be incised and the sac-wall should be dissected out. Hydatids of the brain have been successfully removed in Australia. A cyst of the kidney is removed through a lumbar incision. Omental cysts should be radically removed if possible; if this is not possible, open the abdomen, surround the cyst with gauze, evacuate through a trocar, stitch the cyst-wall to the wound, incise, irrigate, and drain with gauze. Bond advocated evacuating the cyst, closing it with sutures, and dropping it back in the abdomen. Gardner says tapping is dangerous, as it may cause rupture of the cyst. In a hydatid of the liver the abdomen should be opened, the cyst should be surrounded with gauze pads, and tapped with a trocar and cannula. When the cyst

is emptied of fluid it is grasped with forceps and pulled to the incision in the abdominal wall; it is sutured to this incision, the trocar opening is enlarged, and the endocyst is removed by irrigation.* This operation is called *marsupialization.* If the cyst is on the summit of the liver, it may be reached by a transpleural hepatotomy. If aspiration is performed to settle a diagnosis, operate at once after doing it, because of fear that the cyst may leak and disseminate the disease throughout the peritoneal cavity. If hydatid fluid is disseminated throughout the peritoneal cavity, it may or may not lead to the development of new cysts, but it is almost certain to cause a febrile condition known as *hydatid toxemia.*

XVIII. DISEASES AND INJURIES OF THE HEART AND VESSELS.

Heart and Pericardium.—In acute pulmonary congestion the venous side of the heart is overdistended with blood, and the surgeon in desperate cases may tap the right auricle (see Paracentesis Auriculi). Pericardial effusion, if severe, calls for aspiration or incision, and purulent pericarditis demands incision and drainage.

Rupture, Wounds and Injuries.—**Rupture.**—The heart may rupture and cause instant death, but rupture may not be instantly fatal. Curtin reported a case in which death did not occur for over twenty-four hours. Elsner reported a case of rupture in which life was prolonged for ten days. One case lived eleven days. In cases in which death does not occur rapidly the rupture must be so small that very little blood escapes. Rupture occurs in a damaged heart, a heart in which the muscular fiber is fatty, is fibroid, or is necrotic from suppuration. It may be traumatic, resulting from a fall or a blow upon the chest, or non-traumatic, following a great effort or strain. If death does not at once take place the pulse becomes very rapid, there is precordial pain, dyspnea, cyanosis, feeble heart-sounds, rapid respiration, great restlessness, collapse, and syncope, and the development of a triangular area of dulness. Positive diagnosis is impossible. Meyer collected 36 cases of rupture of the heart reported since 1870. Death occurs from accumulation of blood in the pericardium. Aspiration is useless, as fresh blood replaces what is withdrawn. Suturing must fail in non-traumatic cases because of the badly diseased myocardium. In traumatic cases it may possibly succeed.

Wounds of the Pericardium and Heart.—Severe wounds usually, though not always, produce death, but slight wounds may not prove fatal. It is a popular impression that the expression "stabbed to the heart" is another way of saying that instant death has occurred. This view was accepted even by surgeons during many centuries. During the sixteenth century sportsmen found now and then bullets and arrow-tips healed in the heart-walls of animals they had slain. At this time the famous case of a duelist was published by Paré. This man received a sword thrust in the heart, but was able to run after his opponent many hundred feet before falling down in death. (See "An Experimental Investigation of the Treatment of Wounds of the Heart,"

* John O'Conor, of Buenos Ayres, in Annals of Surgery, May, 1897.

by Charles A. Elsberg, in "The Journal of Experimental Medicine," Sept. and Nov., 1899.) From Paré's time until our own it has been recognized by surgeons that a wound of the heart does not of necessity produce immediate death and may even be recovered from.

In 1867 G. Fisher published a study of 452 cases of wound of the heart, and pointed out the surprising fact that from 7 to 10 per cent. of such cases recover. In recent years Rosenthal, Block, Del Vechio, and others have proved by animal experimentation not only that cardiac wounds are not of necessity instantly fatal, and that in some cases they may be recovered from, but that the suturing of such wounds is possible and greatly enhances the chance of recovery. L. L. Hill ("Med. Record," Nov. 29, 1902) shows that although 90 per cent. of heart-wounds are penetrating, only 19 per cent. are immediately fatal. Sudden death occurs when Kronecker's coördination center is damaged. Several times during post-mortem examinations on human beings healed scars have been found upon the heart. The heart has been punctured a number of times accidentally or intentionally, and death has not ensued. John B. Roberts,* of Philadelphia, suggested in 1881 that it would be proper to try to suture wounds of the heart.

Symptoms.—A wound of the heart causes hemorrhage, usually copious; but owing to the interlocking of muscular fibers the hemorrhage is often slight. Bleeding may take place into the pericardial sac in some cases where the pericardium has been injured and the heart has escaped. Such an injury is occasionally inflicted by the sharp end of a fractured rib. The wound is rarely at or near the apex of the sac. In most cases the pleural cavity is opened and severe hemothorax occurs. The lung may or may not be injured. A wound of the pericardium or heart causes profound shock, irregular or very weak pulse, sighing respiration, dyspnea, and, it may be, the signs of hemopericardium, pneumopericardium, or hemothorax. In hemopericardium splashing sounds are heard with the heart-beats and the heart sounds are very feeble. In pneumopericardium there is a tympanitic percussion-note in the area which should exhibit the cardiac dulness. There may or may not be serious external bleeding. Fatal concealed hemorrhage may occur. Pain is constant, and attacks of syncope are the rule. The position of the wound and the evidences of hemorrhage may aid in making the diagnosis. Death is apt to occur suddenly from shock, hemorrhage, and inability of the heart to contract because of the severed fibers, or inability of the heart to dilate because of the pressure of blood in the pericardial sac. If a wound of the pericardium or heart does not cause death during the first day or two inflammation follows (traumatic pericarditis or carditis) and the patient may die of suppurative pericarditis or of empyema.

Treatment.—Wounds of the pericardium and heart should be sutured. The cutaneous surface should be rapidly disinfected, and every effort must be made to antagonize shock during the operation. The patient should be wrapped in hot blankets and surrounded with hot bottles or hot water-bags, or should be placed upon a table composed of pipes in which hot water circulates. The foot of the bed should be raised. Hot saline fluid should be infused into a vein. Adrenalin chlorid may prove of service. The extremities, except the one selected to infuse salt solution in, should be bandaged

* The author, in Progressive Medicine, vol. i, 1899.

(auto-transfusion), an enema of hot coffee and whiskey should be given, and atropin should be given hypodermatically. It is *seldom* proper to give an anesthetic although in some cases a general anesthetic has been administered. Local anesthesia is of course unsatisfactory. If there has been a wound of the cardiac region and the symptoms are threatening to life, *at once* do an exploratory operation (G. T. Vaughan, "Med. News," Dec. 7, 1901). The heart is exposed by resecting several ribs. In a knife-wound of the right pleural cavity and right side of the pericardium Barth, of Danzig, removed 1 inch from each of 3 right costal cartilages (fifth, sixth, and seventh) close at the side of the sternum, and removed also the ensiform cartilage, and 1 inch of the sternum. The same surgeon in the case of a man stabbed in the fourth left intercostal space, removed the fourth and fifth left costal cartilages and part of the sternum ("Deutsche Zeitschrift für Chirurgie," Bd. lxix, No. 1). Schwerin, of Berlin, in a stab-wound of the chest exposed the heart by resecting the fourth and a portion of the fifth left ribs (Proceedings of German Surgical Congress, 1903). Wilms ("Centralblatt f. Chirurgie," Leipzic, vol. xxxiii, No. 22), in a case of gunshot-wound, obtained access to the anterior and posterior surfaces of the heart by a simple intercostal incision. Parrozzani makes a trap-door in the chest, the hinges of the door being the rib-cartilages. In exposing the heart I believe it is best to follow the rule of Giordono, that is, enter along the wound, removing any obstacles that intervene (Barth). It is needless to try to avoid opening the pleura, it was usually opened by the accident, and in any case can very seldom be avoided. The heart is exposed, clots are removed from the pericardial sac, and the sac is irrigated with hot saline fluid. The bleeding may be furious. A non-penetrating wound of the ventricle may bleed so profusely during systole as to resemble a penetrating wound (Sherman). A penetrating wound may bleed most during diastole. The motion of the chest make manipulation difficult. It is wise to insert two traction sutures in order to lift the heart toward the operator. A wound in the heart is sutured with interrupted sutures of silk, which are passed by means of a round, curved needle, and if a cavity of the heart is open, each suture includes the whole thickness of the heart-wall except the endocardium. If possible, the sutures should be tied during diastole, otherwise they are apt to cut out. The pericardium is sutured with silk, or, as was done in one successful case, the sac is packed with iodoform gauze (Rehn's case). It is not absolutely necessary to drain the pericardial sac. Clots are removed from the pleural sac by irrigation with hot saline solution, pulmonary bleeding is arrested by the suture or by packing, and a wound in the lung, especially if it communicates with the air-passages, is sutured if the patient's condition justifies prolonging the operation.*

After such an operation the patient is in great danger, and every effort should be made to save him from shock. In performing operations upon the heart the pleura may be opened by design or by accident. When the pleura is opened, there is always pneumothorax and grave danger of pulmonary collapse and overwhelming shock. It is a great advantage in such cases to have at hand the Fell-O'Dwyer apparatus, which will prevent or amend pulmonary collapse.

Dalton has sutured the pericardium. Rehn in 1896 sutured a wound of the heart and packed the pericardium with gauze, and the patient recovered. Parrozzani successfully sutured a wound of the ventricle. Williams, of

* The author, on "Suture of the Heart," in Progressive Medicine, vol. i, 1899.

Chicago, reports recovery after a stab-wound of the heart, the pericardium having been sutured. Farina in 1896 sutured a stab-wound of the left ventricle, and the patient lived several days. Cappelan sutured a wound of the heart, and the patient lived two and one-half days. Peyrot reports a successful operation for a gunshot-wound of the heart ("Bull. de L'Acad. de Med.," July 29, 1902). Lannay operated. There was a wound of entrance in the left ventricle near the apex and a wound of exit in the posterior surface near the base of the left ventricle. The lung was wounded, pneumothorax existed, and blood emerged from the wound during diastole. The wounds were closed with catgut. The pleura and pericardium were cleansed, partly closed, and drained for forty-eight hours. Barth reported a successful operation for a stab of the right auricle. In this case the internal mammary artery was wounded. In Philadelphia Dr. Stewart, Associate in Surgery in Jefferson Medical College, reported a successful operation for stab-wound of the left ventricle. My colleague, Professor Gibbon, reported 1 successful and 1 unsuccessful case, and Dr. Wilms operated successfully on a case of bullet-wound of the heart ("Centralblatt f. Chirurgie," Leipzic, vol. xxxiii, No. 22). I have never operated for a wound of the heart, but operated unsuccessfully for a stab-wound which opened the pleura, injured the lung, cut a pulmonary vessel, and knicked a piece out of the outer coat of the aorta. L. L. Hill, of Montgomery, Alabama ("Med. Record," Nov. 29, 1902), reports the successful suturing of a stab-wound of the left ventricle of a boy thirteen years of age. The operation was performed eight hours after the stabbing. Sherman, in the address on Surgery delivered before the American Medical Association in 1902 ("Jour. Am. Med. Assoc.," June 14, 1902), gave a table containing 34 cases of heart suture since 1896. Only 2 of these were bullet-wounds, 32 were incised or lacerated wounds. In 32 cases the ventricle was injured; in 2, the auricle. The left ventricle suffered 17 times and the right ventricle 13 times. In 7 cases it was necessary to drain the pericardial and the pleural cavity after suturing; in 4 the pleura only was drained; the other cases were not drained. Five died during the operation; 10 died soon afterward. In 19 the suturing was successfully carried out, and although 6 died later of infection, secondary hemorrhage did not occur. Thirteen recovered and 4 of these recovered in spite of infection. Hill, in the report previously quoted, publishes a table of 39 cases with 14 recoveries, and concludes that: The right ventricle is most often, the left auricle least often, injured; wound of the auricle is more dangerous than wound of the ventricle; and wound of the apex is less dangerous than either. A needle puncture rarely causes serious bleeding from a ventricle, but is very apt to cause severe bleeding from an auricle. A wound received during diastole is less dangerous than one received during systole. Wounds of the right heart bleed more than wounds of the left heart. If operation is performed, the mortality is about 63 per cent.; otherwise it is 90 per cent. Wolff publishes a list of 42 cases with 17 recoveries, 41 were stab-wounds and 1 was a bullet-wound. In this list we find that in 14 cases the right ventricle was wounded, in 19 the left ventricle, in 5 the apex, in 1 the left auricle, and in 1 the coronary artery. In 2 cases no mention is made of the part injured. This writer points out that ligation of 1 coronary artery can be done and recovery follows; wounds of the left ventricle give the best prognosis because the wound is closed by thick edges of muscle; in 37 cases the left pleura was

opened, in 3 the right pleura, and in 2 the pleura was uninjured. In bullet-wounds death usually occurs before operation can be done (Wolff, "Deutsche Zeitschrift für Chirurgie," Bd. lxix, No. 1). Rickets, in May of 1903, estimated that 53 operations were on record with 18 recoveries ("N. Y. Med. Jour.," May 16–23, 1903). Up to the present time (October, 1906) over 100 cases have been operated upon and over 40 per cent. of them have recovered.

If there is suspicion of a heart-wound, perform an exploratory operation. The immediate dangers of the operation are hemorrhage, shock, and the entrance of air. The late dangers are pericarditis, empyema, and pneumonia (Vaughan). Traumatic carditis or pericarditis is treated in the same way as idiopathic cases. Pus in the pericardial sac should be evacuated by resection of the fourth left costal cartilage and incision of the pericardium (von Eiselberg's case).

Pericarditis.—Pericarditis is an infectious condition that may be traumatic or non-traumatic. If pericarditis follows an open wound, it is obvious how the infection must have entered; if it follows a bruise or a contusion, the injury has rendered the pericardium a point of least resistance. In some few cases, which are known as primary pericarditis, it is impossible to determine how the micro-organisms gained entrance. The ordinary form appears as a complication of certain infectious diseases, such as septicemia, pneumonia, rheumatism, and tuberculosis. It may be secondary to some adjacent infection, such as an empyema. A tuberculous abscess may break into the pericardium, and an abscess even from a distant point may burrow into it. It may arise secondary to a distant infection, as a suppurating wound, osteomyelitis, middle ear suppuration, abscess of the mastoid, tonsillitis, abscesses anywhere, peritonitis, and gastric ulcer. It sometimes follows gastro-enterostomy and may arise in an individual with Bright's disease. In a recently-born child infection of the stump of the umbilical cord may be causal of pericarditis. A pericardial effusion in a newly-born child is invariably purulent and in a young child it is usually purulent. A great variety of bacteria may be responsible for pericarditis. The discharge may be serofibrinous; this is an evidence of its being a mild infection, and such a discharge may undergo absorption. On the other hand, the discharge may be purulent, and in such a case cure will never be obtained by absorption of the pus. In pericarditis there is usually some pain in the region of the heart, and this pain is apt to extend into the left arm. The heart is overacting, the heart-sounds are indistinct, the pulse is strong and very rapid, there is an increased area of cardiac dulness, and the patient complains of dyspnea. The temperature is elevated, and a double friction-sound may be made out upon auscultation.

Treatment.—Ordinary pericarditis, without pus-formation or extensive effusion, is managed by the physician; but when there is extensive effusion, it may be necessary to open the pericardium, and if there is purulent effusion the pericardium must be opened. The procedure usually practiced in the past to relieve pericarditis with marked effusion was aspiration. This, however, is extremely dangerous. The heart is not pushed back by the pericardial effusion, but is lifted upward and forward; and it is impossible to select any place for aspiration that assures us that there will be no danger of puncturing the heart. In cases of extensive pericardial effusion, and also in cases

of suppuration within the pericardium, an inch or more of the cartilage of the fourth rib of the left side should be removed or two inches of the fourth rib itself, and the pericardial sac should be formally incised. In this operation it may be necessary to tie the internal mammary artery. The pericardial sac is cleared of purulent material and fibrinous masses by irrigation, and the edges of the pericardial wound are sutured to the edges of the superficial wound and gauze drainage is introduced. Incision is safer and more certainly curative than aspiration; for whereas aspiration might be curative in pericardial effusion, it cannot be so if the effusion is purulent. In 41 cases of purulent pericarditis (Roberts' table of 35 cases and Ljunggren's 6 cases) operated upon 16 recovered. Local anesthesia is safer than general anesthesia.

Phlebitis, or Inflammation of a Vein.—Acute Phlebitis.—Phlebitis may be *plastic* or it may be *infective.* Plastic phlebitis, while occasionally due to rheumatism, to gout, to advanced phthisis, to a febrile malady, or to some other constitutional condition, usually takes its origin from a wound or other injury, from the extension to the vein of a perivascular inflammation, or, in the portal region, from an embolus. Varicose veins are particularly liable to phlebitis. When phlebitis begins a thrombus usually forms (see thrombosis, page 185), because of the destruction of the endothelial coat of the vessel, and this clot may give rise to emboli, may be absorbed, or may be organized. An aseptic clot organizes and the vein becomes permanently narrowed or blocked. A septic clot is apt to soften and break up. In the lower extremities *paraphlebitis* is common with slight involvement of coats, and no clot may form. Clot-formation causes edema. Infective phlebitis is a suppurative inflammation of a vein, arising by infection from suppurating perivascular tissues (*infective thrombophlebitis*). It is not unusually met with in cellulitis or phlegmonous erysipelas, may arise in the lateral sinus as a result of mastoid suppuration, or in the liver from appendicitis or phlebitis of the rectal veins. A thrombus forms, the vein-wall suppurates, is softened and in part destroyed, and the infected clot softens and gives rise to emboli. No bleeding occurs when the vein ruptures or is opened, as a barrier of clot keeps back the blood-stream. The clot of suppurative phlebitis cannot be absorbed and cannot organize. Septic phlebitis causes pyemia, and the infected clots of pyemia cause phlebitis at the points of lodgment.

Phlebitis of the iliac or femoral vein may follow an abdominal operation when there is no evidence of infection. Strange to say, it is most apt to attack the left iliac vein; it matters not upon which side the operation was performed. It may be due to toxins damaging the inner coat of the vein, but feeble circulation is a powerful factor in its production and I believe with Clark that powerful traction on the sides of an abdominal wound may be responsible for it (see thrombosis after abdominal operations, page 188). Vandeveer reported 4 cases in which sepsis was positively absent ("American Medicine," July 13, 1901). I have seen it occur in the left iliac vein after an interval operation for appendicitis. Phlebitis may arise in the vein of one extremity, a clot may form, and this may be absorbed or may organize. Another extremity may be involved afterward or simultaneously.

Symptoms.—The symptoms of plastic phlebitis are pain, tenderness in and around a vein, discoloration over it, and edema below the seat of the

disease. Suppurative phlebitis, besides these conditions, causes the constitutional symptoms of pyemia (page 199).

Treatment.—The treatment of plastic phlebitis of an extremity comprises rest in bed for from four to six weeks, slight elevation of the part, the use of cold for the first twenty-four hours, and then the application of external heat and a flannel bandage. If the patient is gouty or rheumatic appropriate remedies should be given. A clot does not always form in a vein, but

Fig. 140.—Varicose veins.

if one forms there is danger of embolism; hence massage and both active and passive movement are dangerous until the clot becomes firm. When a vein is involved in a suppurative process and septic thrombophlebitis exists, ligate or compress the vein by packing, if possible, above and below the clot, open the vessel, and wash out the infected clot, or, if dealing with an accessible vein, extirpate the involved portion. This plan of treatment is always to be applied in infective thrombophlebitis of the lateral sinus and of the internal saphenous vein. The constitutional treatment is that of pyemia.

Chronic Phlebitis.—This rare condition is known as *phlebosclerosis* and it is a chronic inflammation of the wall of a vein, producing a fibrous change in the vascular coats. It may arise in a part the seat of chronic venous engorgement, but its most frequent cause is syphilis.

Varicose Veins; Phlebectasis, Phlebectasia, or Varix (Figs. 140 and 141).—**Definition and Causes.**—Varicose veins are unnatural, irregular and permanently dilated veins which are elongated and pursue a tortuous course. This condition is very common, and 20 per cent. of adults exhibit it in some degree in one region or another. Some facts indicate hereditary predisposition. In over 80 per cent. of cases the trouble begins before the age of twenty-five. The causes of varicose veins are said to be obstruction to venous return and weakness of cardiac action, which lessens the pro-

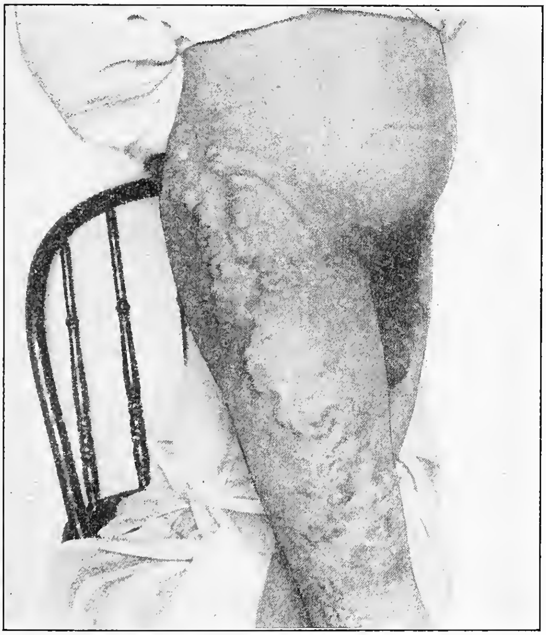


Fig. 141.—Varicose veins.

pulsion of the blood-stream. A. Pearce Gould says obstruction is not a cause, because in pregnancy varicose veins may be seen early, before the womb is much enlarged. The real cause is probably a predisposition to the growth of vein-tissue, which leads to valve failure and a regurgitation of blood from the deep veins into the superficial venous channels (A. Pearce Gould, in "Lancet," March 1 and 15 and June 7, 1902). As Billroth said over thirty years ago, sudden obstruction causes edema and gradual obstruction a free collateral circulation. Neither sudden nor gradual obstruction can cause varicosity unless the veins are predisposed by a tendency hereditary or acquired.

Varicose veins may occur in any portion of the body, but are chiefly met with on the inner side of the lower extremity, in the spermatic cord, and in the rectum. Varix in the leg is met with most commonly during and after

pregnancy and in persons who stand upon their feet for long periods. It is especially common in the long saphenous vein, which, being subcutaneous, has no muscular aid in supporting the blood-column and in urging it on. The deep as well as the superficial veins may become varicose. Verneuil maintained that varix of the superficial veins is almost always secondary to varix of the deep veins, a radical view which seems improbable. It is certain, however, that after contusions of the leg it is not unusual for the deep veins to become filled with clot and for the superficial veins to dilate notably. By the term "*caput medusæ*" is meant dilated veins radiating from the umbilicus. The veins of the esophagus may become varicose, and this malady is commonly unrecognized clinically. Varicose veins are in rare instances congenital; but they are most often seen in the aged, and usually are first observed between the ages of twenty and forty. They are more common in women than in men, owing, it is believed, to the influence of pregnancy.

Varix of the spermatic cord is known as "*varicocele*." It is apt to appear about the time of puberty, and most adult men have at least a slight varicocele. Varix is more likely to appear in the left spermatic vein than in the vein of the right side, because the left spermatic vein has no valves (Brinton).

Varicose tumors of the rectum constitute "*hemorrhoids*" or "*piles*." Piles are caused by obstruction to the upward flow in the hemorrhoidal veins, either by obstructive liver disease, enlargement of the uterus or prostate, or the presence in the rectum of fecal masses in a person habitually constipated.

A vein under pressure may dilate more at one spot than at another, the distention being greatest back of a valve or near the mouth of a tributary. The valves become incompetent and the dilatation becomes still greater. Callender has pointed out that varix is apt to begin where the deep vessels join the superficial veins. At this point Treves says three forces meet: the blood-column above, the valve below, and the force of the blood-current. At the spot where the pressure is greatest the vein-wall dilates, and from this dilatation the blood-current is deflected and causes another dilatation higher up and on the opposite side of the vessel. The blood is again deflected and causes another dilatation, and so on (Agnew). The vein-wall may become fibrous, but usually it is thin and sometimes it ruptures. The veins not only dilate, but they also become longer, and hence do not remain straight, but twist and assume a characteristic form. It seems probable that the first step in the process is a growth of new venous tissue (A. Pearce Gould) and then follow lengthening, tortuosity, incompetence of the valves, and dilatation of the vessel.

Delbet* points out that varicose veins of the leg, which begin in the thigh, result from valvular incompetence; varicose ulcers arise from variations of pressure due to valvular incompetence. This incompetence of the valves does harm by allowing the intravenous pressure to equal the pressure in the arterioles, a condition which arrests capillary circulation, causes congestion, and greatly lowers tissue-resistance. Incompetent valves also favor ulceration by developing a *vicious venous circle* first described by Trendelenburg. Blood passing through this circle loses nutritive elements. Trendelenburg has described the vicious circle as follows: Blood in the saphenous vein flows toward the periphery instead of toward the center, because of in-

* Sem. méd., Oct. 13, 1897.

competent valves—it passes into the veins which connect the superficial veins with the deep veins and then enters the tibial and peroneal veins. It passes from the tibial and peroneal into the popliteal and femoral veins, and some of it leaves the femoral vein and again enters the saphenous.

The skin over varicose veins in the leg is often discolored by pigmentation due to red blood-cells having escaped from the vessel and broken up. The tissues around a varicose vein become atrophied from pressure, and it is not unusual to meet with a very large vein whose thin walls are in close contact with skin. In this condition rupture and hemorrhage are probable. When the vein-wall forms a pouch-like dilatation the condition is spoken of as a *cyst*. Varicose veins are apt to inflame, and thrombosis frequently occurs. When a thrombus forms, especially if the patient walks about, emboli may be broken off and carried into the circulation, but emboli formation is not nearly so common as a result of thrombosis in a varicose vein as in thrombosis in an undistended and unelongated vessel. In varicose veins of the thigh, however, the chance of embolism following thrombosis is much greater than when the veins of the leg alone are involved. In some elderly people thrombus actually effects spontaneous cure. When a thrombus organizes, more or less calcification is apt to ensue, and a *vein-stone* or *phlebolith* is formed. After middle life many varicosities remain stationary or cease to give trouble. The chief complications of varicose veins of an extremity are thrombosis, edema, violent hemorrhage from rupture, phlebitis, eczema, and chronic ulceration.

Treatment.—The treatment of varix may be *palliative* or *curative*, but whichever plan is followed, the surgeon should endeavor first of all to remove the exciting cause. An essential part of palliative treatment is to attend to the general health, to keep up the force and activity of the circulation, and to prevent constipation. Massage is useful, especially alcohol frictions, if eczema is absent, and *cold* baths are always forbidden (Bennett). The patient should exercise regularly in the open air and should lie down for a time, if possible, every afternoon. Instead of lying down for a time during each day, he may sit down and elevate the legs, resting them on a table, and thus assuming a position supposed to be peculiarly American. If there is no pain, distinct discomfort, or edematous swelling, a support is unnecessary, but if these conditions exist it is needed. If a support is required in varix of the leg, use a flannel roller or a perforated rubber bandage applied over a long stocking. Such a bandage supports the veins and drives the blood into the deeper vessels which have muscular support. The use of a rubber pad filled with glycerin and applied over the saphenous vein so as to support the blood-column and act as a valve, has been recommended. Locally, in varicocele, pour cold water upon the scrotum twice a day and order the patient to wear a suspensory bandage. Locally, in hemorrhoids, use injections of ice-water and astringent suppositories. A purely local varix should be excised, because there is always danger of injury, and consequently of hemorrhage or thrombosis. If the superficial veins have dilated because of thrombosis of the deep veins and edema exists, operation is contraindicated, as its performance might lead to permanent edema. If the disease involves the leg only, operative treatment is rarely required and may even do harm. Such cases are operated upon if there are cyst-like dilatations, if thrombi form, and, as

Bennett points out, if a thin-walled vein crosses the tibia, and is thus exposed to the danger of injury and thrombosis.*

If the leg is involved in the process, and the saphena in the thigh is also varicose, operation should be performed.

If a thrombus forms in a varicose vein, tie the vein above and below the clot, divide the vessel in two places, and remove the vein and the clot within it. Thrombosis of a varicose vein is not so apt to lead to emboli as thrombosis in a non-varicose vein, but it may do so, and the condition is dangerous.

If edema is marked, and increases in spite of properly applied bandages, etc., it probably signifies clot-formation, and the patient should remain in bed until this question is determined. Hemorrhage from a ruptured varicose vein of an extremity is usually readily arrested by compression and elevation.

The radical treatment of varix of the leg often does good, often relieves some annoying condition, but rarely absolutely cures (W. H. Bennett). There are several methods of operation: ligation with excision of part of the vein, exposure and ligation of the vein below the saphenous opening, or circular incision around the leg (see Operations upon Vessels).

Nevus.—(See Tumors.)

Arteritis, or inflammation of an artery, is *acute* or *chronic.*

Acute Arteritis.—Slight inflammation is by no means unusual, but severe arteritis is decidedly rare. It may follow direct injury or arise secondarily to a perivascular inflammation. An artery is very resistant to the spread of inflammation, but we sometimes encounter suppurative arteritis in a suppurating area. Arteritis may arise in the course of an infective malady, being produced by germs, but it is also found in intoxications, and is then due purely to toxins. It may occur in the eruptive fevers, in influenza, typhoid fever, acute rheumatism, gout, syphilis, and diphtheria, septicemia and septic intoxication. Ford points out that acute arteritis developing during acute or chronic infections is particularly apt to arise in the lower extremities (Ford, "Thèse de Paris," 1901). Toxins or bacteria usually reach the artery in the main blood-stream, but may be lodged in the vessel-wall by the lymph or the flow in the vasa vasorum. The inner coat of a portion of an artery becomes lined with inflammatory exudate and the coats are infiltrated with small cells. Often parietal thrombi form. Sometimes, though rarely, the vessel is completely blocked by thrombosis. In acute suppurative arteritis pus accumulates in the arterial wall, a clot forms in the lumen, and the coats of the vessel undergo necrosis and give way. Violent hemorrhage may thus arise, but often, in thrombo-arteritis as in thrombophlebitis, rupture does not cause hemorrhage. Acute arteritis, if non-bacterial in origin, is usually recovered from with slight structural change. Infective arteritis is recovered from if the causative germ is not very virulent or if the toxin is not present in excessive quantity. Acute arteritis may terminate in arterial obstruction with or without gangrene, permanent dilatation, arterial rupture, or chronic arteritis.

Symptoms.—The symptoms may be merged with those of an acute or chronic intoxication or infection, or with those of a local perivascular inflammation. In arteritis arising during infections the symptoms appear abruptly and the onset is marked by great pain. Ford studied 18 cases in influenza.

*W. H. Bennett, Lancet, Oct. 15, 1898.

He says it attacks particularly persons over thirty years of age, occurs in one leg or both, arises most commonly during convalescence, but may not begin until the individual is apparently well. There is pain and tenderness over the vessels, low surface temperature, paresthesia, and mottled skin (Ford, "Thèse de Paris," 1901). The artery may be obstructed, and if a large vessel is blocked, the pulse below the clot is lost. The block may be temporary or persistent. Gangrene may follow. Ford points out that if the artery only is blocked, the gangrene is dry; but if the vein also is occluded it may be moist. I have seen two cases of dry gangrene following influenza.

Treatment.—Secure rest in bed; elevate the extremity slightly, relax it, smear the skin over the inflamed vessel with ichthyol ointment, or mercurial ointment, or follow Ford's advice and use methyl salicylate or an ointment of salicylic acid, turpentine, and belladonna. Wrap the part in cotton and surround it with bottles or bags filled with warm water. If a patient is very restless, a splint must be used. It may be necessary to give morphin for pain and any infection or toxemia must be combated with appropriate remedies.

If gout, rheumatism, or syphilis is regarded as causative, proper remedies must be given. It is most important to maintain the secretion of the kidneys. If abscesses form in a septic case, they must be opened and drained. If a large artery of an extremity become occluded, raise the foot about two inches from the bed, wrap the foot and leg in cotton wool, apply a flannel bandage from the toes up, and surround the limb with bags of warm water—not hot water. Hot water would take more blood to the region of the block than could be distributed. If gangrene occurs, amputation is necessary.

Chronic Endarteritis (Arteriosclerosis, Atheroma, Arteriocapillary Fibrosis).—By these terms we mean thickening of the walls of the arteries, limited in area or widespread, due to inflammation or degeneration of the middle coat, the media undergoing hypertrophy, and the intima fibrous hyperplasia (Wm. Russell, "Brit. Med. Jour.," June 4, 1904). Atheroma is used to designate the disease when it attacks the large vessels and is characterized by advanced degeneration. Chronic endarteritis is due to increase of blood-pressure. Increase of blood-pressure means increase of arterial tension, because the lumen of the vessels is lessened and the heart works more strongly to urge the blood along, and finally hypertrophy of the middle coat occurs. The persistence of arterial contraction which causes increase of blood-pressure may be brought about by kidney disease, hard work, violent strains, heart disease, care and anxiety, worry and mental strain, habitual gluttony, syphilis, gout, rheumatism, lead-poisoning, diabetes, and acute infections like typhoid fever and influenza. It may arise in an old man who has not suffered particularly from any of the above-named causes, or may occur prematurely from heredity. It is a true saying of Cazalis that "A man is as old as his arteries," and a young man dilapidated by syphilitic disease or alcohol may have diseased arteries, and hence be really older than a healthy man of sixty. The aorta, of all vessels, is most prone to suffer. The large vessels are more apt to be diseased than the small, but even the arterioles can be involved. The arteries of the stomach, liver, and mesentery are rarely sclerotic. In arteriosclerosis connective tissue is substituted for the normal elements of the vascular wall and this tissue undergoes hyperplasia and subsequent contraction and induration. If the mass of proliferating fibroblasts

undergoes fatty degeneration, *atheroma* is said to exist, and an atheromatous vessel may be calcified by deposition of lime salts. When fatty degeneration occurs, the endothelium is destroyed, the vessel-wall is damaged, and the blood may obtain access to the deeper coats. Atheroma is a frequent cause of thrombosis, aneurysm, senile gangrene, and apoplexy.

A sclerosed artery is rigid, non-contractile, and inelastic, and the parts it supplies are cold, congested, and ill-nourished, and often edematous. When the caliber of arteries remains narrowed because of persistent contraction or of arteriosclerosis, the heart is obliged to overwork and in consequence undergoes hypertrophy. The hypertrophied heart finally dilates. If a hypertrophied heart exists with diseased arteries, apoplexy or aneurysm is apt to occur (Nammack, "Med. Record," Oct. 26, 1901). Syphilitic arteritis is characterized by an enormous growth of granulation tissue from the inner coats of arteries of small size (*obliterative endarteritis*). Calcification of an artery may be secondary to fatty change, or may occur primarily from deposit of lime salts in the middle coat. *Periarteritis* is inflammation of the sheath and outer coat. An acute arteritis is always local, but a chronic arteritis may be general.

Treatment of Chronic Arteritis.—In treating chronic arteritis, endeavor to antagonize the dangers to which the patient is obviously liable. Forbid alcohol as a beverage, though a little whiskey may be taken at meals to aid digestion. Maintain the activity of the skin by daily baths, and of the kidneys by diuretic waters. A daily bowel movement should be secured. The diet is to be plain and is to contain a minimum of nitrogen. If syphilis has existed, occasional courses of iodid of potassium are to be given. If the arterial tension at any time becomes inordinately high, administer nitroglycerin. One danger to which the patient is liable is apoplexy; hence excitement and violent exercise are to be avoided. Another danger is senile gangrene; hence the patient should wear woolen stockings, put a bottle or bag of warm water to his feet at night, and be careful to avoid injuring his toes or feet especially when cutting his corns. A bag of very warm water is dangerous and may actually excite gangrene. When a patient with atheroma has dyspnea and is of a livid color, or when the arterial tension is very high, a moderate blood-letting (sixteen to eighteen ounces) does good, and may prevent or arrest edema of the lungs. Still another danger is aneurysm, which may appear suddenly from rupture or gradually from progressive distention.

Aneurysm.—An aneurysm is a pulsating sac containing blood and communicating with the cavity of an artery, and formed partly or entirely by the arterial walls or a fusiform dilatation of an artery. Some restrict the term "true aneurysm" to a condition of dilatation involving *all* the coats of the vessel. We shall consider, with Heath, a *true* aneurysm to be one in which the blood is included in one or more of the arterial coats, and a *false* aneurysm to be a condition in which the vessel has ruptured or has atrophied and the aneurysmal wall is formed by a condensation of the perivascular tissues.

Forms of Aneurysm.—The following forms of aneurysm are recognized:

1. *True aneurysm*—one whose sac is formed of one or more arterial coats.

2. *False aneurysm*—one whose sac is formed of condensed perivascular tissues and contains no arterial coat.

3. *Traumatic diffuse aneurysm*—a false aneurysm due to a wound or traumatic rupture of a blood-vessel. At first the blood is widely diffused and unlimited by any sac or capsule, later a limitation or encapsulation may occur by the condensation of tissue, any wound being healed. A traumatic diffuse aneurysm may follow a puncture or an incised wound of an artery, the injury causing the aneurysm directly. It may follow an effort or a strain, the injury indirectly causing the aneurysm by acting on a diseased vessel. As Barwell says, the term traumatic diffuse aneurysm is an extremely bad one, as the term aneurysm conveys the idea of some sort of a sac. In this condition there is no true sac and blood is either unlimited or limited only by condensed tissue.

4. *Diffused aneurysm*—a term used to mean a ruptured aneurysm, the blood being diffused in the tissues and either unlimited or limited only by condensed tissues. The term should be limited to conditions in which the effusion of blood is slow and trivial. If the effusion is large and rapid the term *ruptured aneurysm* is preferable.

5. *Consecutive aneurysm*—results from the rapid growth of a sacculated aneurysm. At a certain portion of the sac of a true aneurysm the arterial coats give way completely and at this point blood is limited only by clot and by condensed perivascular tissue. The blood is not diffused but is encapsuled, partly by the old sac, partly by condensed tissues, aided it may be by bone and fascia.

6. *Fusiform* or *tubulated aneurysm*—a variety of true aneurysm, the sac being spindle-shaped and formed, as Matas states, "at the expense of the artery," the artery dilates, the continuity of the parent artery is interrupted for a variable length, and is lost in the sac, to be restored once more as a normal vessel at the outlet of the aneurysm ("Transactions of Am. Surg. Assoc.," 1905). Such an aneurysm has, of course, two openings. This form, according to Matas, comprises 66.6 per cent. of all aneurysms.

7. *Sacculated aneurysm*—a common form of aneurysm, in which the dilatation is like a pouch, arising from a part of the arterial circumference and joining the lumen of the vessel by a single aperture. As Matas points out, the parent artery is involved in but a portion of its circumference, the continuity of the vessel is not lost, the arterial caliber is maintained at a nearly normal diameter, and "the sac is simply grafted or attached to the artery by a narrow neck, forming a sort of diverticulum of variable shape and dimensions" ("Proceedings of Am. Surg. Assoc.," 1905). Such a sac has but one orifice. The opening from the artery into the sac is called the *mouth;* around and just above the mouth is the *neck;* the balance of the sac is much larger than the neck and is called the *body*. A sacculated aneurysm may arise from an artery of normal size, from a dilated artery or from a fusiform aneurysm. A sacculated aneurysm of unknown cause is called a *spontaneous aneurysm;* one which is due to injury is called a *traumatic* aneurysm. The first step in the formation of a sacculated aneurysm is stretching or giving way of an area of the middle coat (media), followed by a gradually advancing stretching and dilatation of corresponding areas of the outer coat (adventitia) and the inner coat (intima).

8. *Dissecting aneurysm* (Shekelton's aneurysm)—a pouch-like dilatation of an artery due to the blood which has gained access to the middle coat through

an atheromatous ulcer or a minute rupture of the inner coat. It used to be taught that the blood flows between the media and adventitia; we now know that it flows between the layers of the middle coat. The outer wall of the aneurysm consists of adventitia and a portion of the middle coat. It may or may not join the lumen of the artery at another point by a fresh aperture in the intima. Dissecting aneurysm is practically only met with in the aorta. It is most common in the thoracic aorta. About eighty cases have been reported.*

9. *Arteriovenous aneurysm*, which is divided into aneurysmal varix, or Pott's aneurysm, where there is direct communication between a vein and an artery; and varicose aneurysm, where there is communication between an artery and a vein by means of an interposed sac.

10. *Acute aneurysm*—a cavity in the walls of the heart, which cavity communicates with the interior of this organ, and which is due to suppuration in the course of acute endocarditis or myocarditis.

11. *Aneurysm by anastomosis* (see Angiomata).

12. *Aneurysm of bone*—an inaccurate clinical term used to designate a pulsatile tumor of bone.

13. *Circumscribed aneurysm*—when the blood is circumscribed by distinct walls.

14. *Cirsoid aneurysm*—a mass of dilated and elongated arteries shaped like varicose veins and pulsating with each heart-beat.

15. *Cylindrical aneurysm*—a dilatation which maintains the same dimensions for a considerable space.

16. *Embolic* or *capillary aneurysm*—dilatation of terminal arteries due to emboli.

17. *Spontaneous aneurysm*—non-traumatic in origin.

18. *Miliary aneurysm*—a minute dilatation of an arteriole.

19. *Secondary aneurysm*—one which, after apparent cure, again pulsates, the blood entering by means of the anastomotic circulation.

20. *Verminous aneurysm*—one containing a parasite. This form of aneurysm is met with in the mesenteric artery of the horse.

The sac of a sacculated aneurysm is at first composed of at least two of the arterial coats, reinforced by the sheath and perivascular tissues. After a time the blood-pressure distends the sac, and the inner and middle coats either stretch with interstitial growth or—what is more common—are worn away and lost. When all the coats are lost, and the blood is sustained only by the sheath and surrounding tissue, a true aneurysm becomes a false or consecutive aneurysm, the limiting tissues and sheath being condensed, thickened, and glued together. This limiting process is deficient in the brain; hence cerebral aneurysms break soon after their formation. When all the arterial coats are lost, the blood-pressure, acting on the tissues, finds some spots less resistant than others, the blood follows the lines of least resistance, the aneurysm grows with great rapidity, and soon ruptures externally or into a cavity.

An aneurysm may rupture into a cavity (pleural, pericardial, or peritoneal), into the perivascular tissues, or through the skin. Rupture into the tissues may produce pressure-gangrene. When rupture occurs through the skin the

* Coleman, in Dublin Jour. Med. Sciences, Aug., 1898.

hemorrhage is not often instantly fatal, but during several days recurs again and again in larger and larger amounts. The pressure of an aneurysm causes atrophy of tissues, hard and soft, bones and cartilages being as easily destroyed as muscles and fat. Sometimes the perivascular tissues inflame and suppurate, and the sac is opened rapidly by sloughing. An aneurysm usually progresses toward rupture, the slowest in this progression being the fusiform dilatation, which may exist for many years, but which finally is converted into the sacculated variety.

In some rare instances there takes place spontaneous cure, which may result from laminated fibrin being deposited upon the walls of the sac as the blood circulates through it. This laminated fibrin is known as an "active clot," and eventually fills the sac. The weaker and slower the blood-stream, the greater is the tendency to the formation of an active clot; hence any agent impeding, but not abolishing, the circulation aids in the deposition. This weakening and slowing of circulation may be brought about by great activity of the collateral circulation diverting most of the blood from the area of disease. Sometimes a clot breaks off from the sac-wall and plugs the artery beyond the aneurysm, and the anastomotic vessels, enlarging, divert the blood-stream. A large aneurysm, falling over by its own weight upon the vessel above the mouth of the sac, may, in very unusual cases, diminish the blood-stream. The development of another aneurysm upon the same vessel nearer to the heart weakens the circulation in and may cure the older one. Inflammation occasionally forms a clot. The tissues about an aneurysm tend to contract when arterial force is lessened; hence tissue-pressure may more than counteract blood-pressure when the circulation is feeble. Clotting of the blood contained within a sac; circulation through the aneurysm having ceased, causes a "passive clot." A passive clot, which occasionally induces cure, may arise from a twist of the neck of the sac preventing the passage of blood; from the lodgment of a clot in the mouth of the sac; and from inflammation. Spontaneous cure is, unfortunately, very rare.

Causes of Aneurysm.—Gradual distention of arterial coats which are in a condition of arterial sclerosis, or of coats whose resisting power is lowered because of atheroma, may cause aneurysm. Hence the causes of sclerosis and atheroma are also causes of aneurysm. The principal cause of aneurysm is increased blood-pressure. This increase may be brought about by severe labor; by sudden strains, as in lifting; by violent efforts, as in rowing in a boat-race; by chronic interstitial nephritis; by hypertrophy of the heart; by alcoholic excess; and by syphilis. Arterial disease is commonest in the larger vessels, and in the aged, but it may occur in youth. When an aneurysm follows a strain, it may be due to laceration of the media and loss of resistance at a narrow point. The intima may lacerate, permitting the blood to come in contact with the media or causing blood to diffuse between the coats (dissecting aneurysm). When an embolus lodges in an artery the vessels may become aneurysmal on the proximal side of the clot. The embolus, if infective, causes softening, and if calcareous causes laceration (Osler). Colonies of micrococci may cause aneurysm.* The parasite *strongylus armatus* causes aneurysm of the mesenteric arteries in horses. Suppuration around a vessel weakens its coats and tends to aneurysm by inducing acute arteritis

* See Osler on "Malignant Endocarditis."

and softening. Sometimes an individual develops multiple aneurysms the origins of which are absolutely unknown. A cut or puncture of a healthy artery may lead, after the surface wound heals, to the development of an aneurysm. Such an aneurysm does not differ in symptoms or treatment from the other form.

The constituent parts of an aneurysm are (1) the wall of the sac; (2) the cavity; (3) the mouth; and (4) the contents.

Symptoms of Aneurysm.—The formation of an aneurysm, when sudden, is occasionally, though rarely, appreciated by the patient, and is described by him as a feeling of something having given way. In most instances the feeling of beating and the discovery of the lump are the first intimations that anything is wrong. An oval or globular, soft, elastic, and pulsatile protrusion develops in the line of an artery. It is usually quite evident to the touch that the sac contains fluid, but sometimes in old aneurysms the sac feels firm or even hard, because of the deposit of fibrin upon its inner surface. In a partially consolidated aneurysm pulsation may be slight or even inappreciable. The protrusion instantly ceases to pulsate and almost disappears on making firm pressure on the artery above. On relaxing the pressure the pulsatile

Fig. 142.—Radial pulse-tracings in aneurysm of right brachial artery: 1, Left radial pulse; 2, right radial pulse (after Mahomed).

enlargement at once reappears. Direct pressure upon the tumor may cause it to almost disappear. Pressure upon the artery below causes the tumor to enlarge. The pulsation is expansile—that is, the sac expands in all directions during every cardiac contraction—and if an index-finger be laid on each side of the tumor so that the points nearly touch, each pulsation not only lifts the fingers, but it also separates them. On placing a stethoscope over the aneurysm or over the vessel below the aneurysm there is imparted to the ear a distinct bruit which travels in the direction of the blood-stream, is systolic in time, and is usually blowing in character. In some cases bruit is absent (when a sacculated aneurysm has a very small mouth, when the circulation is tranquil, or when the sac is full of blood and clot). When bruit is absent it may sometimes be developed by muscular exercise or raising the affected limb (Holloway). In rare cases there may be a double bruit. Occasionally in fusiform aortic aneurysm linked with aortic regurgitation a diastolic bruit exists. A bruit is arrested by pressing upon the artery between the aneurysm and the heart.* A patient who has an aneurysm of an extremity complains of a sensation of beating, of weakness or stiffness of the limb, frequently of pain in a nerve, a feeling of fatigue in the muscles, and edema and dilated veins are apt to develop because of pressure upon large veins and loss of *vis a*

* Holloway on "Aneurysm," in Park's "Surgery by American Authors."

tergo in the circulation. The skin over an aneurysm may be normal, may be discolored, may ulcerate, or even slough. The pulse below an aneurysm is weaker than the pulse of a corresponding part of the opposite limb. This is well shown by sphygmographic tracings (Fig. 142). The tracings taken below an aneurysm are rounded without a sudden rise or an abrupt fall. In internal aneurysms pressure-symptoms are marked. Thoracic aneurysm causes intercostal pain; iliac aneurysm causes pain in the thigh. Aneurysm of the thoracic aorta pressing upon the pneumogastric nerve causes spasmodic dyspnea, and upon the recurrent laryngeal, causes hoarseness, which may be associated with loss of voice, cough, and laryngeal spasm, and is due to unilateral abductor paralysis. Pressure upon a bronchus or the trachea causes dyspnea from obstruction, dysphagia, and cough from laryngeal spasm. Pressure upon the cervical sympathetic first causes dilatation and later contraction of the pupil of the same side. An aneurysm in the neck may interfere with the cerebral circulation and produce vertigo and even attacks of unconsciousness. The evidences of rupture of an aneurysm of an extremity into the tissues are loss of distinctness of outline and increase in area of the tumor, weakening or disappearance of both bruit and pulsation, absence of pulse below the aneurysm, severe pain, edema and coldness of the surface, shock, and possibly syncope. External hemorrhage may arise; the tissues may become extensively infiltrated with blood; sloughing or gangrene may ensue. Death is frequent, and only in very rare cases does spontaneous cure take place. Rupture of a large aneurysm into a cavity causes intense pallor, advancing weakness, syncope, and death.

Diagnosis.—A cyst or abscess over a vessel may show transmitted pulsation which is not expansile, and the tumor does not disappear when pressure is made upon the vessel above it. The pulsation ceases when the growth is lifted off the vessel, or when the position is changed so as to permit it to fall away from the vessel. There is no true bruit, and the history is widely different. A growth under a vessel may lift the vessel and simulate an aneurysm, but the pulsation is not noted in the entire growth, the growth does not disappear on proximal pressure, and there is only a false, and never a true, bruit. The larger the growth under a vessel, the less is the pulsation, because of pressure narrowing the caliber of the vessel. A sarcoma, especially a soft sarcoma attached to the bone, and also a nevoid mass, pulsate and often have a bruit; the tumor never disappears from proximal pressure, though it may slowly diminish in size, to gradually enlarge again when pressure is withdrawn. These growths do not feel fluid, and are rarely circumscribed. An aneurysm may cease to pulsate from consolidation leading to cure, or from rupture. Rupture of a large aneurysm into a cavity induces deadly pallor, syncope, and rapid death. Rupture of an aneurysm of an extremity into the tissues is made manifest by a sensation of something breaking, by pain, by sudden increase in size, by diminution or absence of bruit and pulsation, by absence of pulse below the aneurysm, by swelling and coldness of the limb, and by shock.

Treatment.—In inoperable aneurysms *general, medical,* and *dietetic* treatment must be tried. A chief element in treatment is rest in bed to diminish the rapidity and force of the circulation and favor fibrinous deposit. Valsalva long ago suggested rest, occasional bleeding, and a diet just above

the point of starvation. Tuffnell's plan is to reduce the heart-beats by rest and mental quiet, and to rigidly restrict the diet so as to diminish the total amount of blood and render it more fibrinous. Liquids are restricted in amount, and the patient lives through each twenty-four hours upon four ounces of bread, a very little butter, eight ounces of milk, and three ounces of meat. This plan is pursued for several months if possible, or it is employed for several weeks, intermitted for a short period, the rigid diet again returned to, and so on, over and over again. There can be no doubt that Tuffnell's treatment sometimes cures aneurysm by decidedly lowering the blood-pressure. Many who suffer from aneurysm may be permitted to go about, taking their time about everything and avoiding work, worry, and excitement. The diet should be low and non-stimulating, and the bowels must be maintained in a loose condition.

Even in an operable case diet and rest are of importance. The patient should remain in bed for a number of days before operation, the daily diet consisting of ten or twelve ounces of solid food with a pint of milk. If the circulation is very active, use aconite and allay pain by morphin.

Iodid of potassium in doses of 20 grains undoubtedly does good in aneurysm and not only in syphilitic cases. It seems to lower the blood-pressure. Balfour taught that it thickened the walls of the sac. Osler says it relieves the pain. Iron, acetate of lead, and ergotin are prescribed by some. Digitalis is contraindicated, as it raises the blood-pressure. S. Solis Cohen has used with some success the hydrated chlorid of calcium. Morphin and bromid of potassium are occasionally useful to tranquilize the circulation, allay pain, or secure sleep. Aconite and veratrum viride have long been employed.

Lancereaux and others claim that hypodermatic injections of gelatin at some indifferent point may cure aortic and subclavian aneurysm. In 1896 Dastres and Floresco proved that gelatin injected in the blood increases coagulability. Later Lancereaux and Paulesco showed that injections into the subcutaneous tissue act similarly. Carnot pointed out that gelatin applied to a wound may arrest bleeding. How gelatin acts is uncertain, but that it does increase blood-coagulability seems proved. The value of injections of gelatin for aneurysm is in dispute. Lancereaux warmly advocates its use for sacculated aneurysm and says that after the first dose the aneurysm is seen to shrink and the pulsation is observed to lessen. He injects it slowly and with aseptic care into the subcutaneous tissue of the thigh, using normal salt solution containing from 5 to 10 per cent. gelatin. He never injects less than 5 gm. He gives an injection every tenth to fifteenth day and administers from ten to twenty injections. But the treatment is not free from danger; several deaths have taken place, and several persons have died from tetanus. Care must be taken not to inject gelatin into a vessel, and it must never be thrown about the aneurysmal sac. It irritates the kidneys and its use is contraindicated in renal disease. The injections cause much pain, and it is very doubtful if they do any real good in aneurysm. If used, it should be given at the temperature of the body, and not over 3 gm. should be administered at one dose. A 10 per cent. solution is the proper strength and from 10 to 20 c.c. the correct dose. Gelatin can be given by the mouth. When thus given it is not so powerful, but its coagulating property is not destroyed by digestion. Gelatin in normal salt solution is known as Car-

not's solution. *Carnot's solution* is best prepared by Sailer's formula, as follows (Joseph Sailer, in "Therapeutic Gazette," August, 1901): Take 5 gm. of common salt, 1 liter of distilled water, and 100 gm. of gelatin. Bring the water to a temperature of 80° C. and slowly stir in the gelatin until it is all in solution. Remove the solution from the stove, cool it to 40° C., add to it the white of one egg, and stir for several minutes, and then put the flask on the stove and boil the fluid. The white of egg coagulates and clears the solution. Filter through gauze and then through paper. Place the fluid in test-tubes, each of which will contain 10 c.c., and insert a cotton plug in the mouth of each tube. Sterilize by putting the tubes in a steam sterilizer for fifteen minutes on three successive days. When we wish to use a tube, place it in a cup of hot water until the gelatin liquefies, pour the gelatin into a sterile glass, and draw it up into a sterile syringe. When kept several weeks the tubes dry out.

Other expedients sometimes used in the treatment of aneurysm are: the kneading of the sac to release a clot, in the hope that it will plug the mouth of the sac or the artery beyond it—this is dangerous; electricity; electrolysis; the injection of an astringent liquid; the insertion of a fine aspirating needle and the pushing through it into the sac of a large quantity of silver wire, in the hope that it will aid in whipping out fibrin. Some physicians have inserted needles and horsehair.

Treatment by Pressure.—Instrumental pressure is made by applying two Signorini tourniquets or some specially devised apparatus to limit the flow of blood through an aneurysm without entirely stopping it, the aneurysmal sac being felt to still slightly pulsate. In some situations Lister's abdominal tourniquet is applied; in other regions we may use Tuffnell's compress, which is like a spring truss and is strapped in place. A heavy body suspended over the artery and resting part of its weight upon the vessel has occasionally brought about cure. Compressing instruments can be worn for from twelve to sixteen hours at a time; usually they are removed to permit sleep and are reapplied the next day, and so on for several days. Before applying the compress be sure the sac is full of blood, and render this certain by applying for a few minutes distal compression. This method may cure, but it is very painful. It cannot be used successfully in treating aneurysm of the axillary, subclavian, or carotid artery. It aids in the formation of an active clot.

Digital pressure, made with the thumb aided by a weight, and maintained for many hours by a relay of assistants, has cured many cases. This method may be used alone or may be used as an accessory to instrumental pressure. Its chief field is in the treatment of aneurysm for which other methods are inapplicable (orbit and root of neck). It entirely cuts off the blood and promotes the formation of a passive clot. If cure does not take place in three days, abandon pressure. It must often be abandoned far earlier because of pain.

Direct pressure upon the sac has been used in aneurysm of the popliteal artery, the pressure being obtained by flexing the leg; and in aneurysm of the brachial artery pressure has been applied at the bend of the elbow by flexing the elbow. The pressure of a hollow rubber ball has been used in aneurysm of the subclavian.

Rapid pressure completely arrests the passage of blood through the sac

for a limited time, and is applied while the patient is under the influence of an anesthetic. Take, for example, a case of popliteal aneurysm: the patient is placed under the influence of ether; two Esmarch bandages are used, one being applied to the limb from the toes up to the lower limit of the aneurysm, and the other from the groin down to the upper limit of the sac, and the Esmarch band is fastened above the upper bandage. This procedure stagnates the blood both in the veins and in the arteries, and the sac remains full of blood. Pressure is thus maintained for three or four hours, and on removing the Esmarch apparatus a tourniquet is put on the artery above the aneurysm and partly tightened in order to limit the amount of blood passing through and thus prevent the washing away of clot. This method of rapid pressure sometimes cures by forming a passive clot, but it sometimes results in gangrene. It was devised by John Reid.

Operative Treatment: By the Ligature.—Ligation of the main artery is, as a rule, the best procedure. The methods of ligation are—(1) the method of Antyllus; (2) extirpation of the sac; (3) the method of Anel; (4) the method of Hunter; (5) the method of Wardrop; and (6) the method of Brasdor.

In the *method of Antyllus* (Fig. 143), as usually described, the sac itself is attacked. The artery is ligated immediately above and below the sac, the sac is opened and its contents turned out, or the sac is extirpated. As a matter of fact, Antyllus advocated applying a ligature on each side of the sac and opening the tumor in order to evacuate its contents, but he distinctly opposed extirpation because of its danger. All we know of Antyllus is found in the writings of Oribasius, who lived in the fourth century (B. G. A. Moynihan, in "Annals of Surgery," July, 1898). Syme maintained many years ago that incision of the sac is the proper operation for aneurysm of the gluteal, iliac, carotid, and axillary arteries, but Syme's method is productive of fearful hemorrhage and the plan of Antyllus is vastly better. Syme opened the sac, inserted his finger and plugged the artery toward the heart until a ligature was applied and tied, and packed the sac with lint.

Extirpation of the sac, if practised, should be carried out after applying a ligature on each side after the method of Antyllus. It was originally practised by Philagrius and was reintroduced by Purmann in 1699 (Moynihan).

Extirpation finds warm advocates in Delbet, Littlewood, and Moynihan. Moynihan claims that, as compared with distal ligature, there is a greater chance of recovery, no chance of recurrence, less risk of gangrene, and complete recovery from troubles due to nerve interference ("Annals of Surgery," July, 1898). Extirpation is the best operation for traumatic aneurysm, but if the vessel is seriously diseased near the sac some other method should be employed. The operation is growing in favor and will probably in most instances become the operation of choice ("Annals of Surgery," July, 1898).

The Method of Anel.—In Anel's method the artery is ligated above the sac, and so close to it that there are no anastomotic branches between the sac and the ligature (Fig. 144). It is used only for traumatic aneurysms, and is never employed when the vessel is diseased beyond the aneurysm. Extirpation is preferable to Anel's operation.

The Method of Hunter.—This operation, which is the modern method of ligation, was devised by the illustrious John Hunter. He is said by Sir Everard Hume to have recognized the fact that the vessel adjacent to an aneurysm was apt to be diseased, and he discovered the anastomotic circulation. Putting together these two facts, he devised the operation which goes by his name. It consists in applying a ligature between the heart and the aneurysm, but so far above the sac that collateral branches are given off between it and the point of ligation (Fig. 145). This operation, which is done upon a healthy area, does not permanently cut off all blood, but so diminishes the force and frequency of the circulation that an active clot forms within

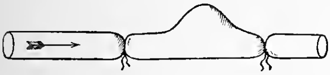


Fig. 143.—Old operation of Antyllus for aneurysm ("Am. Text-Book of Surgery").

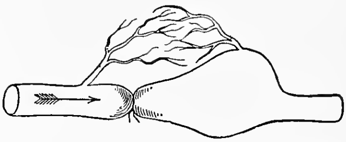


Fig. 144.—Anel's operation for aneurysm ("Am. Text-Book of Surgery").

the sac. Thus is lessened the danger of secondary hemorrhage and of gangrene. According to Stimson ("New York Med. Jour.," July, 1884), Hunter really builded better than he knew, for he sought only to tie the artery without opening the sac and at a healthy point, but said not a word about the necessity of having branches between the sac and the ligature or about the desirability of diminishing the flow of blood instead of cutting it off completely (Moynihan, in "Annals of Surgery," July, 1898). Hunter tied the artery in the region now known as Hunter's canal. Scarpa introduced the custom, which we

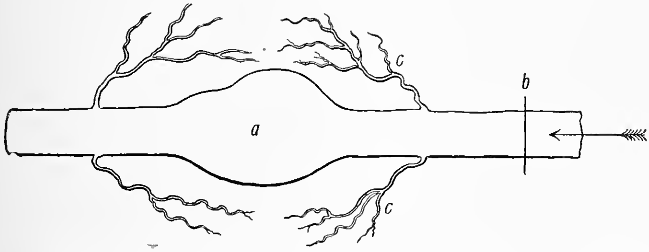


Fig. 145.—Hunter's method of ligating for aneurysm: *a*, The aneurysm; *b*, the point of ligation; *c*, the branches between the aneurysm and the ligature. The arrow shows the direction of the blood-current.

still follow, of tying it in Scarpa's triangle. The Hunterian method is, in the majority of cases, the proper operation for aneurysm. In some cases, pulsation does not return after tightening the ligature; in most cases, however, it reappears for a time after about thirty-six hours, but is weak from the start, constantly diminishes, and finally disappears permanently. Previous prolonged compression by enlarging the collateral branches permits strong pulsation to recur soon after ligation, and thus militates against cure; hence it is a bad plan to use pressure in cases admitting of ligation, and in which the success of pressure is very doubtful. Occasionally after Hunter's operation the sac suppurates, producing symptoms like those of abscess. Sup-

puration may occur between the first and the thirty-second week after ligation.* When pus forms, open freely as we would open an abscess, and, if no blood flows, treat as an abscess, but have a tourniquet loosely applied for several days ready to screw up at the first sign of danger. If hemorrhage occurs, tie the vessel above and below the aneurysm, open the sac, and pack with iodoform gauze. If bleeding recurs, there is no use reapplying the ligature and there is little use tying higher up. If dealing with an arm, try the application of a ligature higher up; if dealing with a leg, amputate at once.

Distal Ligation.—When an aneurysm is so near the trunk that Hunter's operation is impracticable, or when the artery on the cardiac side of the tumor is greatly diseased, distal ligation may be employed. Distal ligation forms a barrier to the onflow of blood, collateral branches above the aneurysm enlarge, the blood-current is gradually diverted, and a clot may form within the aneurysm. Distal ligation is used in some aneurysms of the aorta, iliacs, innominate, carotids, and subclavians. It occasionally causes rupture of the sac of the aneurysm. I have obtained one notably successful result in an

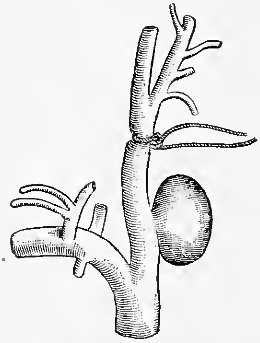


Fig. 146.—Brasdor's operation (Holmes).

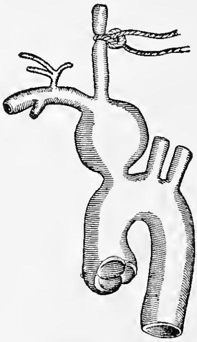


Fig. 147.—Wardrop's operation (Holmes).

aneurysm of the innominate artery by ligation of the carotid and subclavian of the right side.

The operation of Brasdor consists in tying the main trunk some little distance below the aneurysm (Fig. 146). It completely arrests circulation in the sac.

The operation of Wardrop consists in tying one of the branches of the artery below the aneurysm. Wardrop originally advocated ligation at a point where there is no intervening branch between the sac and the ligature. Later he advocated ligation at a point where there is an intervening branch. Since then it is the custom to consider Wardrop's operation to be the ligation of one branch below the aneurysm, as shown in Fig. 147. The circulation is but partially arrested by Wardrop's operation. An *x*-ray picture should be taken in every case of aortic aneurysm. Such a picture may aid us in coming to a conclusion as to which vessel or vessels to tie.

Matas's Operation (Aneurysmorrhaphy).—This procedure was proposed by Matas in 1902 ("Transactions of Am. Surg. Assoc.," 1902; "Annals of Surg.," Feb., 1903; "Transactions of Am. Surg. Assoc.," 1905).

*See the case described by Sir Astley Cooper.

One procedure, applicable to ordinary fusiform aneurysms, is called *obliterative endoaneurysmorrhaphy without arterioplasty* (Fig. 148). "No attempt is made to reconstruct the parent artery (arterioplasty), and the arterial orifices are simply obliterated by suture." Simply by sutures applied within the incised sac, the sac is cut off from the circulation without disturbing adjacent collaterals and without interfering with the nutrition of the sac walls. In 15 cases collected by Matas all recovered, there was not one case of secondary hemorrhage, gangrene, or relapse.

A modification of the above operation applied to sacculated aneurysms in which there is one orifice of communication with the artery is called *endoaneurysmorrhaphy* with *partial arterioplasty* (Fig. 148). The sac is opened, clots are washed away, the opening into the artery is closed by a continuous suture passing through all the coats of the sac at the edge of the opening into the artery. Thus blood is excluded from the sac, the lumen of the artery is not, however, obliterated and the blood-supply of parts beyond is not interfered with. After closing the opening into the artery the sac is obliterated by rows of sutures inserted in the walls. Matas reports 4 cases operated upon successfully by this plan. In a fusiform aneurysm with a firm and resisting sac wall, and in which there are 2 openings near together on the floor of the sac, *endoaneurysmorrhaphy* with complete *arterioplasty* may be performed (Fig. 148). This operation restores arterial continuity, a new channel being made out of the sac walls "by simply holding these over a rubber guide (tube or catheter) and suturing them firmly together so as to restore the continuity of the artery lost in the sac." The catheter is withdrawn before the final sutures are tied. This operation has been performed successfully by Morris and also by Craig. Some surgeons are fearful that such an operation will be followed by relapse, and one of the reported cases did relapse. Matas says that preservation of the arterial lumen is "only indicated positively in the sacciform aneurysms with a single opening where the parent artery already exists as a formed vessel and in which the closure of the fistulous opening can be accomplished with the greatest facility and simplicity" (address delivered at the Medical Assoc. of Alabama, April 22, 1906).

Matas points out that suture of an aneurysm is indicated only when certain essentials exist.

1. The situation of the aneurysm must admit of the control of the circulation temporarily on the proximal side of the sac. In most aneurysms of the extremities this is done by the elastic band of Esmarch. In the neck and abdomen both the cardiac and peripheral sides of the main vessel must be secured by traction loops and compression.

2. The sac must be freely opened in a longitudinal direction. Its walls must not be dissected and must be separated as little as possible from surrounding tissue.

3. Every orifice opening into the sac must be thoroughly exposed so that they can be closed by sutures. The suture material is chromic gut, the number being 1, 2, or 3, according to the size of the aneurysm.

Fig. 148, *A* to *H*, show Matas's various operations. For a full description of them see the previously quoted articles of the author. I believe that the Matas operation is a very notable advance in surgery, that it is safer than older methods, and much less apt to be followed by gangrene. The idea seems

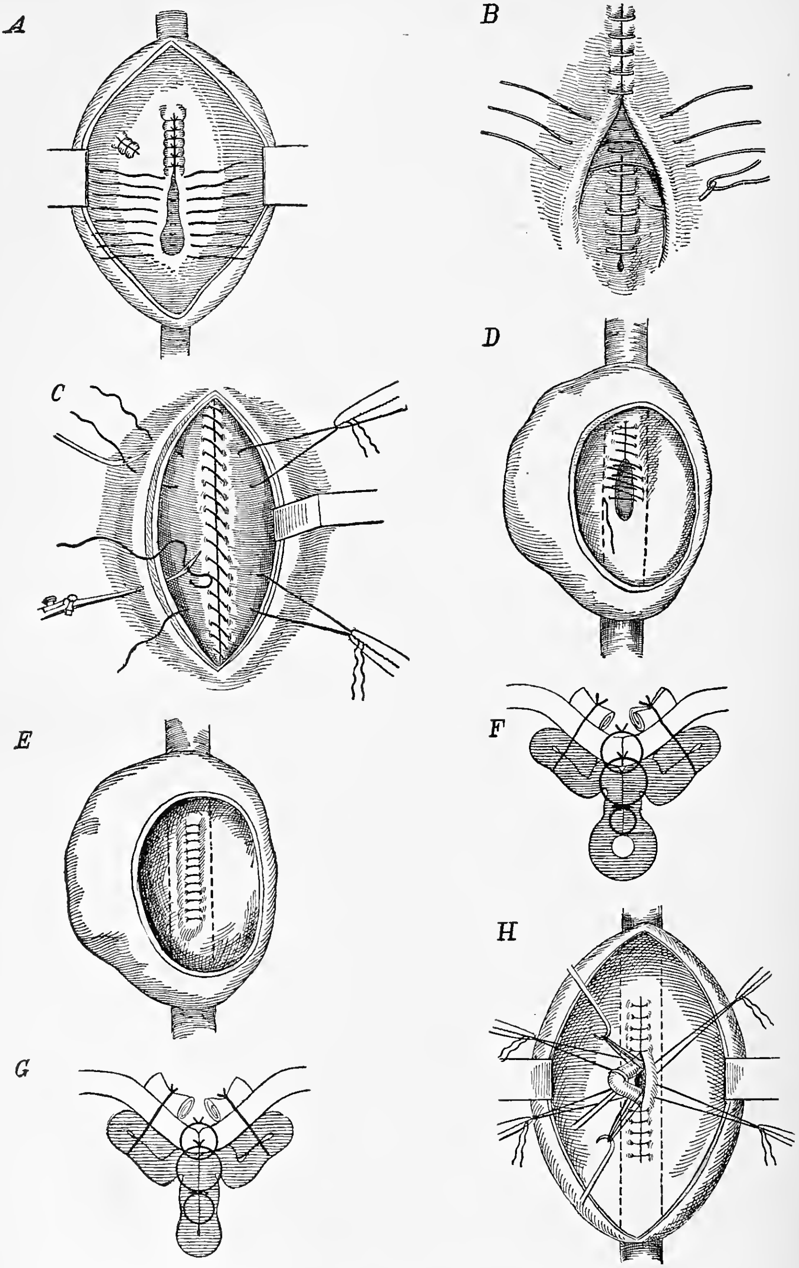


Fig. 148.—The radical cure of aneurysm based upon arteriorrhaphy (Matas): *A*, First tier of sutures in a fusiform aneurysm; *B*, second tier of sutures, some of which are tied; *C*, sutures to approximate the walls of the aneurysm; *D*, suturing the opening in a sacculated aneurysm—the main artery is not obliterated; *E*, opening completely closed; *F*, diagram of cross-section of parts after complete obliteration of sac but with restoration of blood-channel; *G*, diagram of cross-section of parts after complete obliteration of sac and blood-vessel; *H*, operation for fusiform aneurysm when we wish to restore the blood-channel—sutures applied over a rubber tube, most of the sutures tied, tube withdrawn, and remaining sutures tied.

to be general that Matas always seeks to restore arterial lumen. This is not the case. He only seeks to do this in exceptional cases. The essence of his method is to cure the aneurysm by sutures within the sac and by obliteration of the sacs. I have performed successfully, on a case of ruptured fusiform aneurysm the operation of obliterative endoaneurysmorrhaphy.

After operating for aneurysm of an extremity by the ligature or by sutures elevate the limb slightly, keep it warm by wrapping in cotton and surrounding with bags of warm water, and subdue arterial excitement. When gangrene of a limb follows ligation, await a line of demarcation, and when it forms, amputate. Rupture of the sac after ligation may produce gangrene or be associated with suppuration, the first condition demanding amputation, and the second incision for drainage.

Injection of coagulating agents into the sac (ergot, perchlorid of iron, etc.) is very dangerous and is to be utterly condemned. It may lead to suppuration, gangrene, rupture, or embolism.

Manipulation to break up the clot was suggested by Sir Wm. Fergusson and has been practised. The object aimed at is to have a fragment of clot block up the vessel upon the peripheral side of the artery and act like a distal ligature. The method is dangerous, especially in carotid aneurysm, and should never be employed.

Amputation, instead of distal ligation, is performed in some perilous cases of subclavian aneurysm.

Electrolysis.—An attempt may be made to at once coagulate the blood in the sac, or from time to time an endeavor may be made to produce fibrinous deposits, but the first method is the better. It is, however, seldom possible to at once occlude a sac, and pulsation, which is for a time abolished, usually recurs as the gas present is absorbed. Use the constant current. Take from three to six cells which stand in point of size between those used for the cautery and those used for ordinary medical purposes. A platinum needle is attached to the positive pole and a steel needle to the negative pole, each needle being insulated by vulcanite at the spot where the tissues will touch it. The asepticized needles are plunged into the sac where it is thick, and they are kept near together. The current is passed for a variable period (from half an hour to an hour and a half). This operation is not dangerous. Pressure stops the bleeding. Electrolysis often ameliorates, and sometimes, though very rarely, cures, aortic aneurysms.*

Acupressure consists of the partial introduction of a number of ordinary sewing needles into an aneurysmal sac and leaving them in it for five or six days or more. Professor Macewen introduces a needle, and with it irritates the interior of the sac of an aneurysm, hoping thus to cause deposition of leukocytes and clot-formation.

Introduction of Wire.—Insert into the sac a hypodermatic or small aspirating needle, and push through the needle or cannula a considerable quantity of aseptic gold wire, which is allowed to remain permanently. Electrolysis should be combined with the introduction of wire. This operation was first proposed by Corradi. Loreta and Barwell both inserted wire into an aneurysm before Corradi, but Corradi inserted wire and also used electricity. Corradi's operation can be used when distal ligation cannot be carried out,

* See John Duncan, in Heath's Dictionary.

and can be used even when the vessel is extremely atheromatous. It finds its chief use in aneurysms of the thoracic aorta and innominate. In some cases of abdominal aneurysm the belly has been opened and the operation carried out. Some cases have been notably improved, and one of Stewart's cases was apparently cured.* The operation is performed with aseptic care. If the thoracic aorta is to be operated upon, an anesthetic is not required. If the abdominal aorta is to be wired, the patient must be anesthetized, because the abdomen needs to be opened. The wire used must have been previously drawn, so that it will easily pass through a hypodermatic needle and will coil up spirally within the sac (Stewart). The best wire is of silver or gold. It is a great mistake, Stewart says, to introduce a large quantity. He considers that a globular sac three inches in diameter requires from three to five feet, and a sac five inches in diameter requires from eight to ten feet. A hypodermatic needle, insulated up to one-quarter inch of the point, is carried into the interior of the aneurysm through a fairly thick portion of the sac. The required amount of wire is introduced. The wire is attached to the positive pole of the battery. The negative pole is fastened to a large flat piece of clay or a pad of moistened absorbent cotton, and the negative electrode is placed upon the back or abdomen. The current is turned on gradually until the necessary strength is obtained (40 to 80 ma.). When ready to terminate the operation the current is lowered gradually to zero, the needle is withdrawn, the wire is cut off close to the skin, the end is pushed under the skin and the puncture is covered with iodoform collodion. The entire operation requires from three-quarters of an hour to one and a half hours.† A clot forms with considerable rapidity and expansile pulsation may lessen or cease. The operation can be repeated if necessary.

Treatment of Aneurysm following Wound of a Healthy Artery.—The prognosis in such a case is usually extremely good. The treatment is as for the other forms. Extirpation is particularly adapted to such direct traumatic aneurysms in the neck and Matas's operation to those in the extremities.

Diffuse Traumatic Aneurysm.—When an artery ruptures or an aneurysm ruptures and a large mass of blood is extravasated into the tissues, no complete sac exists, and the condition is usually called diffuse traumatic aneurysm. In diffuse traumatic aneurysm, a large, oblong, fluctuating swelling is found. If the rent is large, there are bruit and pulsation. There is no pulsation in the artery below the aneurysm, and the limb is cold and swollen. The skin is at first of a natural color, but later becomes thin and purple.

Treatment.—If an aneurysm ruptures cut down upon the aneurysm, incise the sac longitudinally, and perform Matas's operation. Some surgeons cut down to the aneurysm, tie on each side of the tear, open the sac, and pack it (the operation of Antyllus). If an artery is ruptured, empty the limb of blood, apply an Esmarch band above, and expose the seat of rupture by incision. If possible, suture the opening; if this is not possible, tie the vessel on each side of the rupture and excise the intervening portion. If the main vein is also ruptured, amputate.

* D. D. Stewart, in Phila. Med. Jour., Nov. 12, 1898.

† The above description is condensed from that of D. D. Stewart, in Phila. Med. Jour., Nov. 12, 1898.

Arteriovenous aneurysm was first described by Wm. Hunter in 1757. By the term we mean an unnatural passageway between a vein and an artery, through which passage blood circulates. There are two forms: (*a*) *aneurysmal varix*, or *Pott's aneurysm*, a vein and an artery directly communicating; and (*b*) *varicose aneurysm*, a vein and an artery communicating through an intervening sac. These conditions arise usually from punctured wounds, the instrument passing through one vessel and into the other, blood flowing into the vein, the subsequent inflammation gluing the two vessels together, and

Fig. 149.—Dilatation of veins in arteriovenous aneurysm of the femoral vessels.

the aperture failing to close (aneurysmal varix, Fig. 150). After the infliction of the wound the two vessels may separate; the blood continuing to flow from artery into vein, and the blood-pressure, by consolidating tissue, forming a sac of junction (varicose aneurysm, Fig. 151). Wounds produced by small bullets may result in arteriovenous aneurysm (Matas, in "Transactions of Am. Surg. Assoc.," vol. xix). Aneurysmal varix is a less grave disorder than varicose aneurysm. Arteriovenous aneurysm used to be most frequent at the

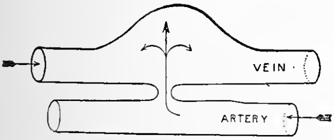


Fig. 150.—Plan of aneurysmal varix.

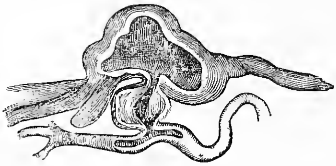


Fig. 151.—Varicose aneurysm (Spence).

bend of the elbow, the vessels being injured during venesection. The condition may occur in the neck, the axilla, the extremities, or the groin. I assisted Professor Keen in an operation upon an aneurysmal varix of the common carotid and internal jugular vein, and assisted Professor Hearn in operating on a varicose aneurysm involving the external iliac vessels. Sir Frederick

Treves operated on a case involving the internal maxillary vessels. Very rarely an arteriovenous aneurysm forms spontaneously. Spontaneous arteriovenous aneurysm is most frequent between the aorta and vena cava. There is no tendency to spontaneous cure in arteriovenous aneurysm. Edema is the rule, muscular atrophy is common, and ulceration or even gangrene of a limb may occur. Matas has collected 17 cases of arteriovenous aneurysm of the subclavian vessels ("Transactions of Am. Surg. Assoc.," vol. xix). In this list is the celebrated case of his own, a traumatic (gunshot) arteriovenous aneurysm in which cure followed operation; in the operation it was necessary to obliterate the artery by ligatures, but the venous orifice was closed by sutures without obliterating the lumen of the vein. In the analysis of Matas's paper 15 cases are used, 2 having been noted too late for incorporation; 9 of the cases resulted from "stab or penetrating cut wounds," 6 from bullets—in 5 of the cases the brachial plexus was injured. In 8 out of the 11 unoperated cases the time after the injury when symptoms of arteriovenous aneurysm was noted is stated; in 1 signs were definite within four hours, in 3 they were noted on the second day, in 3 on the third day, in 1 on the sixth day, in 1 on the eighth day, in 1 on the ninth day, and in 1 a few days later. In 3 of the 15 cases secondary hemorrhage followed the injury. Eleven of the 15 cases were treated expectantly; 1 died from secondary hemorrhage and sepsis 3 weeks after the injury and 10 "survived the immediate effects of the injury, their wounds healing after the cessation of the primary hemorrhage."

In 4 of the 15 cases operation was performed. In 3 the operation was done soon after the injury because of violent secondary hemorrhage. In 1 (Matas's own case) operation was done deliberately to prevent complications. Three of these cases recovered (including Matas's); 1 died of renewed secondary hemorrhage on the twenty-fourth day after operation. Matas points out the fact that in stab wounds of the subclavian vessels the largest proportion of cases die of primary hemorrhage before assistance is obtained, but in a considerable number of cases temporary hemostasis occurs, which is followed by secondary hemorrhages or arteriovenous aneurysm.

Symptoms of Aneurysmal Varix.—The arterial blood is cast forcibly into the vein and as a consequence the vein becomes enlarged, tortuous, and thickened. The scar of a wound is almost invariably apparent. At the seat of vascular trouble the most marked dilatation exists and it is of bluish color. The tumor pulsates markedly, imparts a sensation to the finger like that felt when the hand is laid upon the back of a purring cat. This thrill or vibration is very characteristic. A sound of a hissing or buzzing nature can be easily heard. The tumor at once disappears on pressure being made upon it or on the artery between it and the heart. It is diminished in size by raising the limb, is increased in size by a dependent position of the limb and by compressing the vein between the heart and the tumor. The adjacent veins are dilated and often the dilatation is manifested over a wide area above and below (Fig. 149), and the thrill and bruit are transmitted a considerable distance. If an extremity is involved it is usually edematous. The parts as a rule are painful. The condition progresses, but very slowly, and sometimes years may elapse without any notable aggravation.

Symptoms of Varicose Aneurysm.—In this condition we find many of the symptoms of aneurysmal varix, but in varicose aneurysm pressure over the artery of supply between the heart and the lesion does not cause the entire disappearance of the tumor; the veins collapse, it is true, but a distinct tumor remains which may be emptied by direct pressure.

Treatment.—The prognosis after operation is better than in ordinary aneurysm (Treves), but nevertheless it is wisest to refrain from operating on aneurysmal varix so long as the condition is not progressing obviously, is borne without inconvenience, and is not leading to complications. Varicose aneurysm should be operated upon. If we refrain from operating upon aneurysmal varix the patient should wear a support; but if the part becomes painful or if there seems to be danger of rupture of the vein, each vessel should be tied above and below the opening and a portion of each vessel should be excised, the excised area including the opening. In varicose aneurysm each vessel above and below the sac must be ligated, and the sac and a portion of each vessel should be excised.

Cirsoid aneurysm, or **aneurysm by anastomosis,** consists in great dilatation with pouching and lengthening of one or several arteries. The disease progresses and after a time involves the veins and capillaries. The walls of the arteries become thin and the vessels tend to rupture. Cirsoid aneurysm is most commonly met with upon the forehead and scalp of young people, where it sometimes takes origin from a nevus. It is sometimes seen upon the back or upper extremity. The cause is unknown. Usually there is no assignable cause, but occasionally the condition follows an injury. Pregnancy causes a cirsoid aneurysm to grow rapidly, and so usually does the onset of puberty. Occasionally some of the enlarged vessels fuse and form a great cavity. If rupture occurs, desperate hemorrhage inevitably ensues.

Symptoms.—There is a pulsating mass, irregular in outline, composed of dilated, elongated, and tortuous vessels that empty into one another. The mass is soft, can be much reduced by direct pressure, and is diminished by compression of the main artery of supply. A thrill and a bruit exist.

Treatment.—In treating a cirsoid aneurysm the ligation of the larger arteries of supply is a wretched failure. Subcutaneous ligation at many points of the diseased area has effected cure in some cases, but it has failed in more. Direct pressure is also entirely useless. Ligation in mass has been successful. Destruction by caustic has its advocates. Electropuncture with circular compression of the arteries of supply has once or twice effected a cure. Injection of astringents has been recommended. Verneuil ligated the afferent arteries, incised the tissues around the tumor, and sank a constricting ligature into the cut. The proper method of treatment is excision after exposure and ligation of every accessible tributary of supply. In a very extensive mass extirpation is impossible; hence one of the other methods suggested must be employed. A very considerable mass can be excised, and the resulting wound should be covered with Thiersch skin-grafts.

Wounds of arteries are divided into contused, incised, lacerated, punctured, and gunshot-wounds, and vascular ruptures.

Contused and Incised Wounds.—A contusion may destroy vitality and be followed by sloughing and hemorrhage. A contusion may rupture a

blood-vessel, and is especially apt to do so if the vessel is diseased. Blood is at once effused at the seat of rupture. If an artery is ruptured, there may or may not be a bruit and pulsation over the seat of rupture, pulse is absent below, and the leg below the injury swells and becomes cold. If a large vein ruptures, a blood tumor forms, which does not pulsate and has no bruit, and the limb below becomes intensely edematous. Gangrene is apt to follow the rupture of a main blood-vessel of an extremity. A contusion may rupture the internal and middle coats of an artery, the external coat remaining intact. When this happens the internal coat curls up and the middle coat contracts and retracts, the blood-stream is arrested, and a large clot forms within the artery. If the clot blocks up many collaterals, gangrene will follow, and, as has been pointed out, the gangrene will not be preceded by swelling at the seat of injury, which always occurs if a vessel is ruptured. A contused wound may do little damage, or it may produce gangrene from thrombosis, or it may cause secondary hemorrhage. In an incised wound of an artery there is profuse hemorrhage. The artery after a time is apt to contract and retract, bleeding being thus arrested. A transverse wound causes profuse bleeding, but there is a better chance for natural arrest than in an oblique

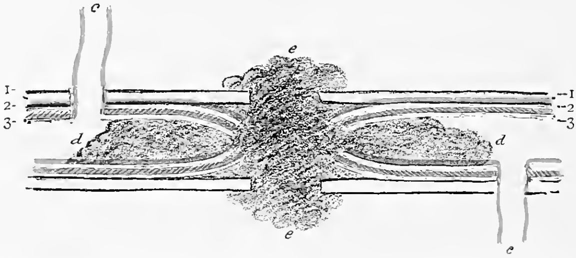


Fig. 152.—Clots formed after division of an artery: 1, 2, 3, Outer, middle, and inner coats; *c*, *c*, branches; *d*, *d*, internal clot; *e*, *e*, external clot.

or in a longitudinal wound. The clot which forms within a cut artery is known as the "internal clot." It used to be taught that the internal clot always reaches as high as the first collateral branch, and subsequently is replaced by fibrous tissue, which permanently obliterates the vessel, and converts it into a shrunken fibrous cord. As a matter of fact, when the parts are aseptic after a ligation the clot is rarely bulky and is often very scanty, repair being quickly effected by proliferation of endothelial cells. Between the vessel and its sheath, over the end of the vessel, and in the surrounding perivascular tissues is the "external clot" (Fig. 152).

A **lacerated wound** of an artery causes little primary hemorrhage. The internal coat curls up, the circular muscular fibers of the media contract upon it, the longitudinal fibers retract and draw the vessel within the sheath, and the external coat becomes a cap over the orifice of the vessel. All of these conditions favor clotting. The vessel-wall is so damaged that secondary hemorrhage is usual.

Punctured Wounds.—In punctured wounds primary hemorrhage is slight unless a large vessel is punctured. Secondary hemorrhage is not

common. Traumatic aneurysm and arteriovenous aneurysm are not unusual results.

Gunshot-wounds of arteries by pistol balls and the balls of large-caliber rifles are apt to be contusions which may eventuate in sloughing and secondary hemorrhage or thrombosis and gangrene. A shell-fragment makes a lacerated wound. A modern rifle-bullet makes a clean-cut division of an artery. Secondary hemorrhage after gunshot-wounds is most likely to occur during the third week after the injury. Partial rupture of an artery may cause sloughing and secondary hemorrhage, thrombosis and gangrene, or aneurysm. A complete rupture constitutes a lacerated wound, and is a condition accompanied by diffuse hemorrhage into the tissues.

Wounds of veins are classified as are wounds of arteries. The symptom of any vascular wound is hemorrhage.

Hemorrhage, or Loss of Blood.

Hemorrhage may arise from wounds of arteries, veins, or capillaries, or from wounds of the three combined. In arterial hemorrhage the blood is scarlet and appears in jets from the proximal end of the vessel, which jets are synchronous with the pulse-beats; the stream, however, never intermits. The stream from the distal end is darker and is not pulsatile. Venous hemorrhage is denoted by the dark hue of the blood and by the continuous stream. In capillary hemorrhage red blood wells up like water from a squeezed sponge, and the color is between the bright red of arterial blood and the dark color of venous blood.

In *subcutaneous hemorrhage* from rupture of a large blood-vessel there are great swelling, cutaneous discoloration, and systemic signs of hemorrhage. If a main artery ruptures in an extremity, there is no pulse below the rupture, and the limb becomes cold and swollen. At the seat of rupture a large fluctuating swelling forms, and sometimes there are bruit and pulsation. If a vein ruptures in an extremity, a large, soft, non-pulsatile swelling arises, there is no bruit, and intense edema occurs below the seat of rupture. Profuse hemorrhage induces constitutional symptoms, and death may occur in a few seconds. Loss of half of the blood will usually cause death (from four to six pounds), though women can stand the loss of a greater relative proportion of blood than men. Young children, old people, individuals exhausted by disease, drunkards, sufferers from Bright's disease, diabetes, and sepsis stand loss of blood very badly. An individual with *obstructive jaundice* is apt to suffer from persistent oozing of blood after operation, an oozing which is particularly persistent and dangerous in obstruction of the bile-ducts due to malignant disease. It not unusually causes death. Generally, after bleeding has gone on for a time, syncope occurs. Syncope is Nature's effort to arrest hemorrhage, for during this state the feeble circulation and the increased coagulability of blood give time for the formation of an external clot. When reaction occurs, the clot may hold and be reinforced by an internal clot, or it may be washed away with a renewal of bleeding and syncope. These episodes may be repeated until death supervenes. Nausea exists and there may be regurgitation from the stomach. Vertigo is present. There is dimness of vision or everything looks black; black specks float before the eyes (muscæ volitantes), or the patient sees flashes of light or colors. There is a roaring

sound in the ears (tinnitus aurium). The patient yawns, is restless, tosses to and fro, and great thirst is complained of. The mind may be clear, but delirium is not unusual, and convulsions often occur. After a profuse hemorrhage an individual is intensely pale and his skin has a greenish tinge; the eyes are fixed in a glassy stare and the pupils are widely dilated, and react slowly to light; the respirations are shallow and sighing; the skin is covered with a cold sweat; the legs and arms are extremely cold, and the body-temperature is below normal. The pulse is soft, small, compressible, fluttering, or often cannot be detected; the heart is very weak and fluttering, and the arterial tension is almost abolished. There is muscular tremor; the patient tosses about, and asks often and in a feeble voice for water. The suffering from thirst is terrible and no amount of water gives relief. There is often dreadful dyspnea, and a man who is bleeding to death grasps at his chest, rises up upon his elbow, and then falls back in a dead faint. Usually reaction occurs, though the patient is obviously weaker than before; again a faint may happen, and so there is fainting spell after fainting spell until death ensues. Convulsions frequently precede death. In hemorrhage the hemoglobin is greatly diminished in amount. In an *intra-abdominal hemorrhage* the above symptoms are noted, and, except in splenic hemorrhage, blood gathers in both loins, and dulness on percussion exists which gradually rises and shifts as the patient's position is shifted. The blood also gathers in the rectovesical pouch in the male, and in the recto-uterine pouch in the female, and may be detected by digital examination. If the spleen is wounded, the blood clots quickly, and an area of dulness, which does not shift and which progressively increases, is noted in the splenic region.

Treatment.—When such a dangerous condition is due to an intra-abdominal hemorrhage, the surgeon at once opens the abdomen and arrests bleeding while the assistants apply the treatment advised in the following remarks. If a large vessel in an extremity has been divided, temporarily arrest bleeding by digital pressure in the wound, or the application of an Esmarch band above the wound (if the bleeding is arterial). In some cases forced flexion is used. In any case lower the head, and have compression made upon the femorals and subclavians, so as to divert more blood to the brain, or bandage the extremities (autotransfusion). Apply artificial heat. The value of adrenalin in restoring or maintaining arterial tension has been demonstrated by Crile. We should give the patient by hypodermoclysis one pint of hot normal salt solution containing one dram of the 1 : 1000 solution of adrenalin chlorid. The fluid is allowed to run in the subcutaneous tissue beneath the breast. The infusion of one pint or more of hot salt solution into a vein is a very valuable remedy; it gives the heart something to contract upon and thus maintains cardiac action. If the depression is very severe, inject ether hypodermatically, then brandy, and then atropin. Strychnin may be given hypodermatically in doses of gr. $\frac{1}{20}$, but atropin is of more service. Digitalin is advised by some, but it is not sufficiently rapid in action. Give enemata of hot coffee and brandy. Apply mustard over the heart and spine. Lay a hot-water bag over the heart.

In hemorrhage from a vessel of an extremity, we temporarily arrest bleeding while bringing about reaction. As soon as reaction is established permanently arrest bleeding by the ligature. In intra-abdominal or concealed hemorrhage

it is not possible to temporarily arrest it and wait for reaction, but the abdomen must be opened and the work proceeded with in spite of the patient's condition. Every moment we wait he is growing worse.

A severe hemorrhage is apt to be followed by fever, due to the absorption of fibrin ferment from extravasated blood and its action upon a profoundly debilitated system. After a severe hemorrhage leukocytes are increased, not only relatively, but absolutely. Red corpuscles are diminished both relatively and absolutely. Hemoglobin diminishes; many of the corpuscles become irregular and microcytes are noticed.

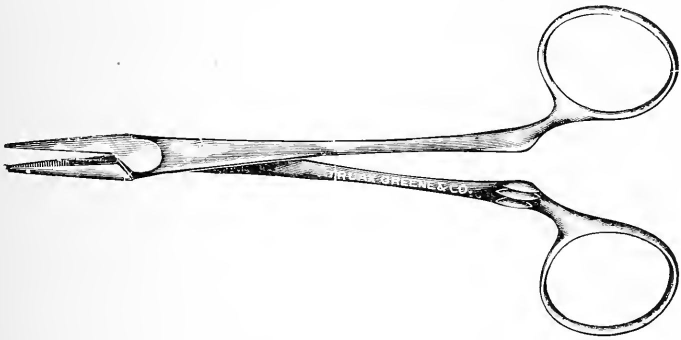


Fig. 153.—Halsted's straight artery forceps.

In treating a patient who has thoroughly reacted after a severe hemorrhage, apply cold to the head. Fluids and ice are grateful. Frequently sponge the skin with alcohol and water. Milk punch, koumiss, and beef-peptonoids are given at frequent intervals.

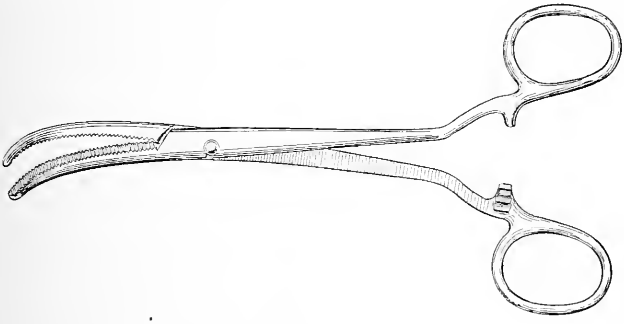


Fig. 154.—Curved hemostatic forceps.

Hemostatic agents comprise (1) the ligature and suture; (2) torsion; (3) acupressure; (4) elevation; (5) compression; (6) styptics; (7) the actual cautery; and (8) forced flexion of limbs.

The ligature was known to the ancients, but was rediscovered by Ambroise Paré. The ligature may be made of silk, floss-silk, or catgut. Whatever material is used must, of course, be rendered aseptic. A ligature should be about ten inches long. The vessel to be tied must be drawn out with forceps and separated for a short distance from its sheath, but must not be separated to any considerable extent; to do so may lead to necrosis of the

vessel and secondary hemorrhage. The hemostatic forceps (Figs. 153, 154, 155) is in most cases a better instrument than the tenaculum (Fig. 156). The tenaculum makes a hole in the vessel, and sometimes a slit-like tear. A portion of this opening may remain back of the tied ligature, the vessel may

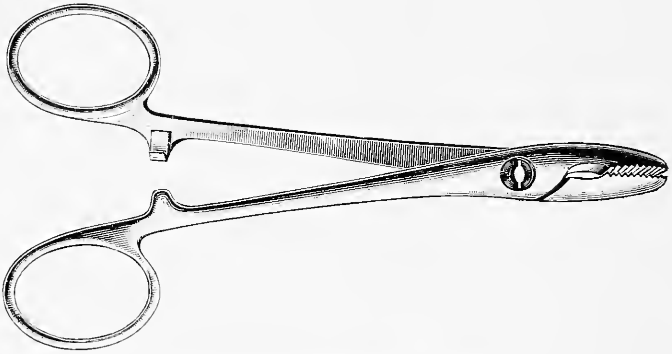


Fig. 155.—Straight hemostatic forceps.

retract a little, or the ligature may slip slightly, and bleeding may occur. When the artery lies in dense tissues or is retracted deeply in muscle or fascia, the tenaculum, when carefully used, is the better instrument. The ligature is tied in a reef-knot (Fig. 157), not in a granny-knot (Fig. 158), and not in a

Fig. 156.—Tenaculum.

surgeon's knot (Fig. 159). It is often the purpose of the surgeon to divide the internal and middle coats of the vessel, and if such is his desire the first knot is firmly tied. The second knot must not be tied too tightly, or it will cut the ligature. The ligature must not be jerked as it is being tied. If a third

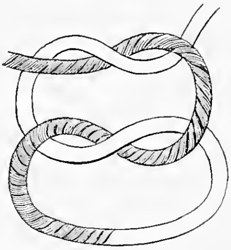


Fig. 157.—Method of tying square or reef-knot.

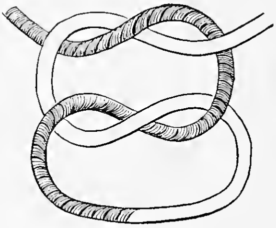


Fig. 158.—Method of tying granny-knot.

knot overlies the first two, the ligature can be cut off close to the knot; otherwise it is cut off so that short ends are left. Both ends of a divided vessel should be ligated. If a vessel is atheromatous, it is not desirable to divide the internal and middle coats. In this case a ligature should be

applied firmly rather than tightly, and another ligature should be put on above it, or ligation can be effected by the stay knot. If an artery is incompletely divided, a ligature should be applied on each side of the wound, and the vessel divided between the ligatures. If a large vein is slightly torn, try to pinch up the vein-walls around the rent and apply a ligature (lateral ligature, Figs. 161, 173). If a vein is longitudinally torn, close the wound

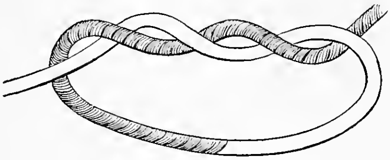


Fig. 159.—Method of tying surgeon's knot.

with a Lembert suture of silk (Ricard, Niebergall, the author and others have done this successfully). Murphy, of Chicago, has recently shown that longitudinal wounds or small lateral wounds of either veins or arteries can be closed successfully with silk sutures, and if a transverse wound includes more than one-half of the circumference of the vessel, after the vessel is completely divided, the ends can be successfully united by end-to-end anastomosis.* After such an operation the vessel is probably ulti-

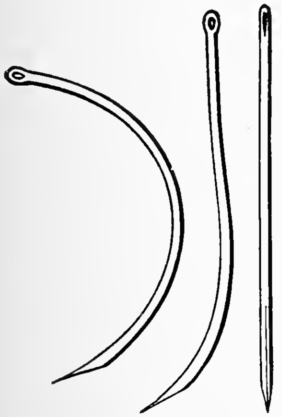


Fig. 160.—Hagedorn's needles.

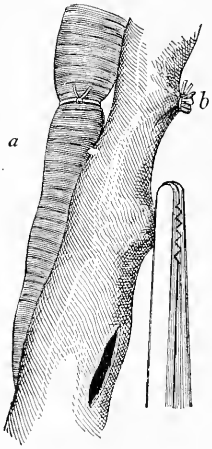


Fig. 161.—Method of controlling hemorrhage by ligature (after Esmarch): *a*, Artery ligated; *b*, lateral ligature of vein.

mately obliterated by endothelial proliferation. It carries blood for a time only, but carries it long enough to lessen the danger of gangrene. While the vessel is closing, the collaterals are dilating. Depage successfully sutured the common carotid artery ("Journal de Chir. et Ann. de la Soc. Belge de Chir.," Jan. and Feb., 1902). Pringle successfully sutured an oblique wound of the external iliac artery. The wound was one-quarter of an inch in length. During the operation pressure was made on the aorta ("Scottish Med. and

* See Medical Record, Jan. 16, 1897.

Surg. Jour.," Oct., 1901). Manteuffel, Marchant, and others have performed like operations. Matas ("Annals of Surgery," Feb., 1903) has collected 30 cases of suture of arteries by lateral or circular arteriorrhaphy. Some surgeons use catgut for sutures; others use silk. There is some danger that aneurysm may form at the region sutured. The rule not to suture but rather do end-to-end anastomosis if more than one-half of the circumference of the vessel is divided is contradicted by A. E. Halstead's case ("Med. Record," July 20, 1901). This surgeon cut two-thirds through the circumference of the axillary artery. He sutured the wound with catgut, passing each stitch through the two outer coats of the vessel. Two months later the radial pulse returned. In longitudinal wounds Halstead recommends the use of a continuous suture. Personally, in suturing vessels I would use fine silk. I have sutured successfully in one case a longitudinal tear in the internal jugular vein and in another case a small transverse cut in the axillary vein. In extensive tears of a vein ligate the vessel in two places and cut between the ligatures. When the parts about an artery are so thickened that the vessel cannot be drawn out, arm a Hagedorn needle (Fig. 160) with catgut and pass the latter around the vessel in such a manner that the catgut will include the vessel with some of the surrounding tissue. Then tie the ligature (Fig. 162). This method is known as the application of a *suture-ligature*, and is pursued in necrosis, atheroma, scar-tissue, sloughing, etc. Never include a nerve of any size in the ligature. If this mode of ligation fails, try acupressure.

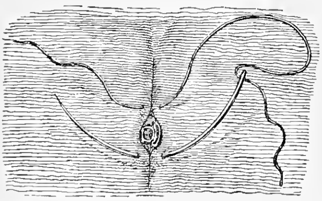


Fig. 162.—Arrest of hemorrhage by passing a suture-ligature.

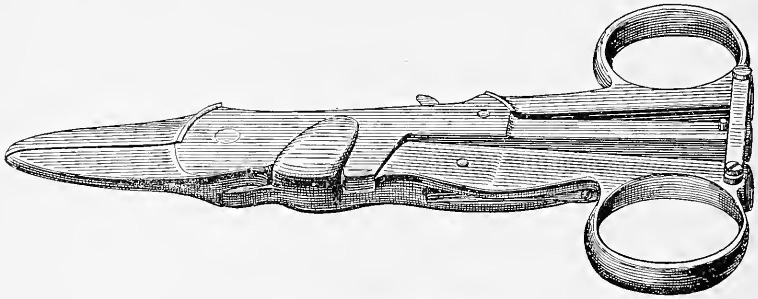


Fig. 163.—Vasotribe of Doyen.

Doyen, when about to tie a thick pedicle, crushes it by means of a very powerful instrument and then ties a ligature about the crushed and attenuated area. The vessels are closed by laceration wide of the ligature and the ligature does not tend to slip. Some trust such a stump without a ligature, but most surgeons prefer to ligate. This instrument is known as the vasotribe or angiotribe and is used particularly in hysterectomy. Fig. 163 shows a vasotribe.

Torsion.—Torsion was practised by the ancients, but was reintroduced in modern times, particularly by Amussat, Velpeau, Syme, and Bryant of London. By means of torsion the internal and middle coats are ruptured, and the external coat is twisted. The middle coat retracts and contracts, and the inner coat inverts into the lumen of the artery. It is a safe procedure, and is practised upon vessels as large as the femoral by many surgeons of high standing. Before the days of asepsis torsion possessed the signal merit of not introducing possible infection in ligatures. At the present time it offers no particular advantage. It is no quicker than the ligature, and damages the vessel so much that necrosis may occur. It cannot be used if the vessels are diseased. In what is known as free torsion the vessel is grasped, drawn out and twisted until the free end of the vessel is twisted off. Limited torsion is more often used. The vessel is drawn out of its sheath by a pair of forceps held horizontally, and is grasped a little distance above its extremity by another pair of forceps held vertically (Fig. 164). The first instrument is used to twist the artery six to eight times.

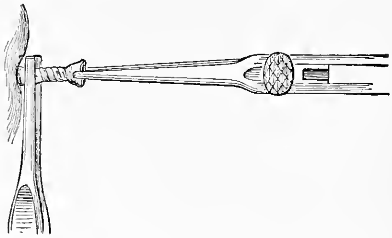


Fig. 164.—Method of controlling hemorrhage by torsion.

Acupressure is pressure applied by means of a long pin. The method of hemostasis by acupressure was devised by Sir James Y. Simpson. A pin is simply passed under a vessel (transfixion), leaving a little tissue on each side between the pin and vessel. A pin can be passed under a vessel, and a wire be thrown over the needle and twisted (circumclusion). The pin can be inserted upon one side, passed through half an inch of tissues up to the vessel, be given a quarter-twist, and be driven into the tissues across the artery (torsoclusion). Some tissue may be picked up on the pin, folded over the vessel, and pinned to the other side (retroclusion). Acupressure is occasionally used to arrest hemorrhage in inflamed or atheromatous vessels, in sloughing wounds, in scar-tissue, and when a ligature will not hold firmly.

Elevation is used as a temporary expedient or in association with some other method. It is of use in a wound of a bursa, in bleeding from a ruptured varicose vein, and is frequently used with compression.

Compression is either direct or indirect—that is, in the wound or upon its artery of supply. In the removal of the upper jaw arrest bleeding by plugging. In injury of a cerebral sinus, plug with gauze. Compression and hot water (115°–120° F.) will stop capillary bleeding. A graduated compress was formerly recommended in hemorrhage from the palmar arch. A compress will arrest bleeding from superficial veins. The knotted bandage of the scalp will arrest bleeding from the temporal artery. Long-continued pressure causes pain and inflammation.

Indirect compression is used to prevent hemorrhage or to temporarily arrest it. It may be effected by encircling a limb above a bleeding point with an Esmarch band or by applying a tourniquet or an improvised tourniquet (Fig. 167). It may also be effected by a clamp. Crile has devised a clamp to effect temporary closure of the carotid artery. In operations about the head

one or both carotids may be closed for a considerable time and bleeding may thus be largely prevented. In 10 cases Crile temporarily closed both carotids. A hypodermatic injection of atropin is given to prevent inhibition, the vessels are exposed, and the clamps are applied with just sufficient firmness to approximate the vessel-walls. No clot will form if the walls are not compressed. The patient is in the Trendelenburg position. If it is found that respiratory difficulty occurs, one clamp must be loosened. After the completion of the operation the patient must be brought to the horizontal before the clamps are removed (Crile, in "Annals of Surgery," April, 1902).

Digital compression is a form of indirect compression. It can be maintained for only a few minutes by one person, but a relay of assistants can carry it out for a considerable time. In compressing the subclavian artery, wrap a key as shown in Fig. 168, and compress the artery against the outer surface of the first rib. The shoulder must be depressed and pressure applied in the angle between the posterior border of the sternocleidomastoid and the upper border of the clavicle. The direction of the pressure should be downward, backward, and inward.

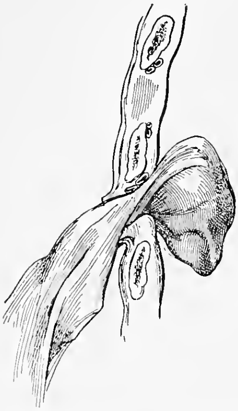


Fig. 165.—Tamponade of intercostal artery (after Von Langenbeck).

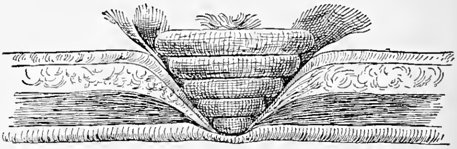


Fig. 166.—Conical aseptic tampon compressing an artery (Senn).

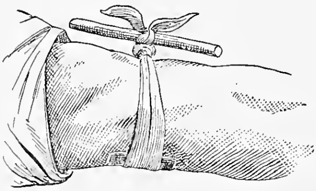


Fig. 167.—Impromptu tourniquet for compressing an artery with a handkerchief and a stick.

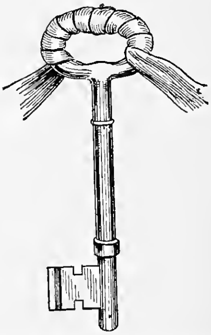


Fig. 168.—Handle of door-key, padded.

The brachial artery can be compressed against the humerus. In the upper part of the course of the artery the pressure should be from within outward (Fig. 169), in the lower part from before backward (Fig. 170). The abdominal aorta can be compressed by Macewen's method (*q. v.*). The common iliac can be compressed through the rectum by means of a round piece of wood known as Davy's lever. The femoral artery can be compressed just below Poupart's ligament against the psoas muscle and head of the femur

(Fig. 171). The pressure should be directly backward. In the middle third of the thigh digital compression is unsatisfactory, and a tourniquet should always be used or an Esmarch band be employed.

Forced flexion is a variety of indirect compression introduced by Adelmann. It will arrest bleeding below the point compressed, but soon becomes intensely painful. Forced flexion can be maintained by bandages. Brachial hyperflexion is maintained by tying the forearm to the arm. It is often associated with the use of a pad in front of the elbow. Genuflexion is maintained by tying the foot to the thigh. It is increased in efficiency by placing a pad in the popliteal space.

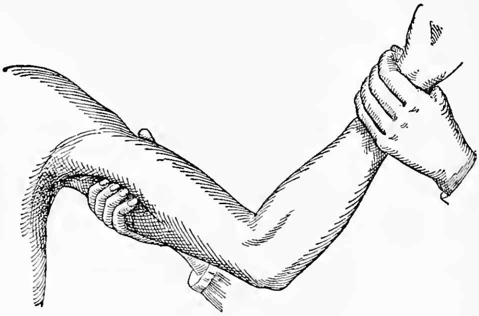


Fig. 169.—Digital compression of the brachial artery.

Styptics.—Chemicals are now rarely used to arrest hemorrhage. In epistaxis we may pack with plugs of gauze saturated with a 10 per cent. solution of antipyrin. In bleeding from a tooth-socket freeze with chlorid of ethyl spray, and then pack with gauze soaked with 10 per cent. solution of antipyrin or pack with dry sponge or styptic cotton (absorbent cotton soaked in Monsel's solution and dried). A bit of cork may be forced into the socket. In bleeding from an incised urinary meatus pack with styptic cotton and compress the lips of the meatus. Cold water, chlorid of ethyl spray, and ice act as styptics by producing reflex vascular contraction. Hot water produces contraction and coagulates the albumin. The temperature should be from 115° to 120° F. A mixture of equal parts of alcohol and water stops capillary oozing.

Fig. 170.—Digital compression of the brachial artery.

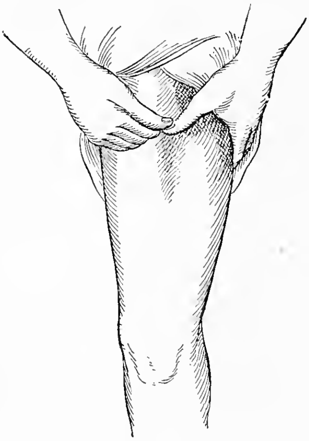


Fig. 171.—Digital compression of the femoral artery.

The Use of Gelatin in Controlling Hemorrhage.—It seems very positively proved that gelatin increases the coagulability of the blood, if given hypodermatically. It has been shown by Horatio C. Wood, Jr. ("American Medicine," May 3, 1902), that, even when administered by the stomach, digestion does not destroy its coagulating effect upon the blood. Carnot, of Paris, used it locally and with success to control epistaxis in a sufferer from hemophilia. He then employed it to arrest bleeding from hemorrhoids, tumors, and incised wounds; and demonstrated in animals that it will arrest oozing from the cut surface of the liver. Carnot used a 5 or 10 per cent. solution. It has been employed with success to control hemorrhage in many situations, is of value when applied locally, and possibly of use when injected subcutaneously.

Intravenous injections are extremely dangerous, and are apt to be followed by embolism. Subcutaneous injections are decidedly painful, and are not altogether safe, producing albuminuria and occasional embolism. Another danger that may follow the subcutaneous administration of gelatin is the development of tetanus, and several cases have been reported. The existence of disease of the kidneys contraindicates the hypodermatic use of gelatin.

It has been successfully used as an enema in intestinal hemorrhage, and as an injection in hemorrhage from the bladder. I have used it with success in arresting bleeding from the cut surface of the human liver; to check bleeding from an incised wound in a victim of leukemia; to arrest the post-operative oozing in sufferers from cholemia; and in several cases of severe epistaxis.

When employed locally in solution, it should be of a strength of from 2 to 5 per cent. in normal salt solution. For hypodermatic use some employ a 5 per cent., some a 2 per cent., and some a 1 per cent. solution. In using a 1 or 2 per cent. solution a very large amount of fluid must be injected. This causes pain; and Sailer maintains that the pain is slight or absent, if the solution is not turbid and if but 10 c.c. of a 10 per cent. solution are injected. The injection may be repeated until from 1 to 3 gm. of gelatin have been administered. It should be injected on the outer side of the thigh, under the breast, or between the shoulder-blades. If the drug is given by mouth, 100 c.c. of a 10 per cent. solution is the dose; and this may be repeated every two or three hours.

On account of the possible danger of the development of lockjaw, great care in sterilizing must always be exercised. The method of preparation suggested by Joseph Sailer will be found of the greatest value. (For the formula for this see page 363).

In view of the fact that gelatin is such an excellent culture-material, whenever it is used in the rectum, nose, pharynx, vagina, or bladder, it should be mixed with some antiseptic agent.

The exact mode in which gelatin acts in producing coagulation is not certain. Floresco maintains that it acts like an acid. Laborde states that undissolved particles of gelatin serve as centers for coagulation. Other experimenters insist that gelatin destroys the leukocytes. and thus liberates fibrin ferment.

Suprarenal extract is a valuable agent to control capillary oozing. It constricts capillaries, and if applied to a mucous membrane will rapidly blanch it. It is extensively used to check bleeding during operations on the nose, throat, larynx, and ear, and to arrest epistaxis and bleeding from the uterus. The solution to employ is adrenalin chlorid of a strength of from 1 : 10,000 to 1 : 1000. A piece of cotton soaked in this solution is pressed lightly upon the part or it is sprayed upon the part by an atomizer ("Practical Therapeutics," by H. A. Hare).

Chlorid of calcium, given internally, favors coagulation of the blood and is used to check oozing or to prevent hemorrhage. It is used particularly in jaundice cases when operation must be performed. If given several times a day for two or three days it increases the coagulability of the blood; but if given for more than four days, actually diminishes it. The initial dose is

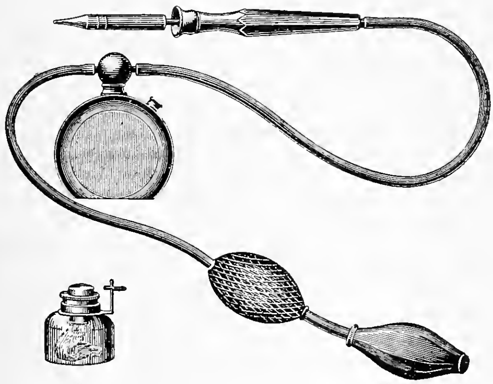


Fig. 172.—Paquelin cautery.

from 15 to 30 grains, then gr. v every hour are given until five or six doses have been taken. It is apt to provoke gastric irritability, and it is often advisable to give it by the rectum.

The actual cautery is a very ancient hemostatic. It is still used occasionally after excising the upper jaw, in bleeding after the removal of some malignant growths, in continued hemorrhage from the prostatic plexus of veins after lateral lithotomy, and to stop oozing after the excision of venereal warts. We are often driven to its use in "bleeders"—that is, those persons who have a hemorrhagic diathesis, and who may die from having a tooth pulled or from receiving a scratch. It will arrest hemorrhage, but the necrosed tissue separates, and when it separates secondary hemorrhage is apt to set in. The iron for hemostatic purposes must be at a cherry heat. The old-fashioned iron, which was heated in a charcoal furnace, is rarely used. It is large, clumsy, and cools quickly if the bleeding is profuse. In an emergency we may heat a poker or a coil of telegraph wire. The best instrument is the Paquelin cautery. The Paquelin cautery consists of an alcohol lamp, a metal chamber containing benzene, a tube of entrance for air containing two bulbs, an exit

tube, and a wooden-handled cautery instrument, the tip of which is hollow and composed of platinum (Fig. 172). This can be kept hot even when bleeding is profuse. If the iron is very hot, it will not stop bleeding completely. In order to use the Paquelin cautery, light the lamp, heat the cautery-tip in the flame, until it becomes red, remove it from the flame, and squeeze the bulb repeatedly until the tip becomes bright red. Each time the bulb not covered with netting is squeezed air is driven through the metal chamber into the tube and cautery, and this air carries with it the vapor of benzene, which passes to the hot tip and takes fire. The degree of heat maintained depends upon the rapidity with which the bulb is squeezed.

Skene has devised a method known as electrohemostasis. He grasps the vessel or tissue with specially constructed forceps, an electric current generates heat, the tissue is cooked, and the walls of the vessel united. A heat of from 180°–190° F. is required. For the small instrument Skene uses a current of 2 ma. and for the larger instrument a current of 8 ma.*

Downes has devised an instrument to apply electrothermic hemostasis in abdominal and pelvic operations. He asserts that by this method an intra-abdominal operation can be rendered bloodless; that the lymph-ducts are sealed and the stump is sterile; that adhesions are less apt to form; and that there is less post-operative pain than if the ligature were used ("Boston Med. and Surg. Jour.," July 10, 1902).

Rules for Arresting Primary Hemorrhage.—1. In arterial hemorrhage tie the artery in the wound, enlarging the wound if necessary (Guthrie's rule). In tying the main artery of the limb in continuity for bleeding from a point below we fail to cut off the bleeding from the distal extremity, and hemorrhage is bound to recur. If the surgeon does not look into the wound, he cannot know what is cut: it may be only a branch, and not a main trunk. The same rule obtains in secondary hemorrhage.†

2. We can safely ligate veins as we would arteries.

3. In a wound of the superficial palmar arch tie both ends of the divided vessel.

4. In a wound of the deep palmar arch enlarge the wound, if necessary, in the direction of the flexor tendons, at the same time maintaining pressure upon the brachial artery. Catch the ends of the arch with hemostatic forceps and tie both ends. If the artery can be caught by, but cannot be tied over the point of, the forceps, leave the instrument in place for four days. If the artery cannot be caught with forceps, use a tenaculum. The ends of the divided vessel can be caught and must be caught even if large incisions are needed to effect it. An incision which will probably always expose the vessel is as follows: Make a cut on a line with the injury from the web of the fingers to above the carpus, separating the metacarpal and carpal bones, until the artery is reached. (This is really Mynter's incision for excision of the wrist.) In former days, if the surgeon found trouble in grasping the ends of the vessel, he applied a graduated compress (Fig. 166). This is applied as follows: Insert a small piece of gauze in the depths of the wound, put over this a larger piece, and keep on adding bit after bit, each successive piece larger than its predecessor, until there exists a conical pad, the apex of which is at the point of hem-

* New York Medical Journal, Feb. 18, 1898.

† For Murphy's observations on anastomosis of vessels, see page 379.

orrhage and the base of which is external to the surface of the palm. Bandage each finger and the thumb, put a piece of metal over the pad, wrap the hand in gauze, place the arm upon a straight splint, apply firmly an ascending spiral reverse bandage of the arm, starting as a figure-of-eight of the wrist, and hang the hand in a sling. Instead of applying a splint, we may place a pad in front of the elbow and flex the forearm on the arm. The palmar pad is left in place for six or seven days unless bleeding continues or recurs. The graduated compress is unreliable, hence it is a dangerous method of treatment. It is an evasion. It should be employed at the present time only as a temporary expedient, until ligatures can be applied. The old rule of surgery was as follows: If bleeding is maintained or begins again after application of a graduated compress, ligate the radial and ulnar arteries. If this maneuver fails, we know that the interosseous artery is furnishing the blood and that the brachial must be tied at the bend of the elbow. If this fails, amputate the hand. At the present day it is hard to conceive of such radical procedures being necessary for hemorrhage.

5. In primary hemorrhage, if the bleeding ceases, do not disturb the parts to look for the vessel. If the vessel is clearly seen in the wound, tie it;

Fig. 173.—Application of lateral ligature to a vein.

otherwise do not, as the bleeding may not recur. This rule does not hold good when a large artery is probably cut, when the subject will require transportation (as on the battle-field), when a man has delirium tremens, mania, or delirium, or when he is a heavy drinker. In these cases always look for an artery and tie it.

6. When a person is bleeding to death from a wound of an extremity, arrest hemorrhage temporarily by digital pressure in the wound and apply above the wound a tourniquet or Esmarch bandage. Bring about reaction and then ligate, but do not operate during collapse if the bleeding can be controlled by pressure.

7. If a transverse cut incompletely divides an artery, it may be found possible and may be considered desirable to suture the cut. Longitudinal cuts can certainly be sutured. If suturing is impossible, or if the surgeon prefers not to attempt it, apply a ligature on each side of the vessel-wound and then sever the artery so as to permit of complete retraction.

8. If a branch comes off just below the ligature, tie the branch as well as the main trunk.

9. If a branch of an artery is divided very close to a main trunk, the rule used to be, tie the branch and also the main trunk. It was thought that if

the branch alone were tied, the internal clot, being very short, would be washed away by the blood-current of the larger vessel. We now know that the clot is not required in repair, and under aseptic conditions it is trivial in size and rarely reaches the first collateral branch. Repair is effected by endothelial proliferation.

10. If a large vein is slightly torn, put a lateral ligature upon its wall (Fig. 173). Gather the rent and the tissue around it in a forceps and tie the pursed-up mass of vein-wall. It is a wise plan to pass the ligature through the two outer coats by means of a needle and tie the knot subsequently. This expedient prevents slipping. If a longitudinal wound exists in a large vein, take an intestinal needle and fine silk and sew it up with a Lembert suture. Transverse wounds can also be sutured.

11. When a branch of a large vein is torn close to the main trunk, tie the branch, and not the main trunk. Apply practically a lateral ligature.

12. If, after tying the cardial extremity of a cut artery, the distal extremity cannot be found, even after enlarging the wound and making a careful search, firmly pack the wound.

13. In bleeding from diploë or cancellous bone, use Horsley's antiseptic wax, or break in bony septa with a chisel, or plug with threads of gauze or scrapings of catgut.

14. In bleeding from a vessel in a bony canal, plug the canal with an antiseptic stick and break the wood, or fill up the orifice of the canal with antiseptic wax; or, if this fails, ligate the artery of supply.

15. In bleeding from the internal mammary artery the old rule was to pass a large curved needle holding a piece of silk into the chest, under the vessel and out again, and tie the thread tightly; but it is better to make an incision and ligate the artery.

16. In bleeding from an intercostal artery make pressure upward and outward, by a tampon (Fig. 165), or throw a ligature by means of a curved needle entirely over a rib, tying it externally; or, what is better, resect a rib and tie the artery.

17. In collapse due to puncture of a deep vessel, the bleeding having ceased, do not hurry reaction by stimulants. Give the clot a chance to hold. Wrap the sufferer in hot blankets. If the condition is dangerous, however, stimulate to save life.

18. In punctured wounds, as a rule, try pressure before using ligation.

19. After a severe hemorrhage *always* put the patient to bed and elevate the damaged part (if it be an extremity or the head).

20. A clot which holds for twelve hours after a primary hemorrhage will probably hold permanently; but even after twelve hours be watchful and insist on rest.

21. If recurrence of a hemorrhage from a limb is feared, mark with anilin or iodin the spot on the main artery where compression is to be applied, apply a tourniquet loosely, and order the nurse to screw it up and to send for the physician at the first sign of renewed bleeding. This must often be done in gunshot-wounds.

22. When the femoral vein is divided high up, the advice commonly given is to ligate the vein and also the femoral artery. Braune taught that because of the venous valves there is no collateral circulation, and to tie the

vein alone renders gangrene inevitable. Niebergall shows that the valves may be overcome by moderate arterial pressure, and thus collateral circulation be established. Hence, when the femoral vein is divided tie the vein, but leave the artery untied, so as to furnish the necessary pressure.*

23. In extradural hemorrhage, trephine. The side to be trephined is determined by the symptoms, and not by the situation of the injury. The opening is made on a level with the upper orbital border and one and a quarter inches behind the external angular process. This opening exposes the middle meningeal and its anterior branch. If this does not expose a clot, trephine over the posterior branch, on the same level and just below the parietal eminence. When the clot is found, enlarge the opening with the rongeur, scoop out the clot, and arrest the bleeding by passing catgut ligatures on each side of the injury in the vessel through the dura, under the artery and out again, and then tying them. If the artery lies in a bony canal, plug the canal with Horsley's wax. In subdural hemorrhage open the dura and endeavor to ligate. If this procedure is impossible, pack with *one* piece of iodoform gauze.

24. In hemorrhage from a cerebral sinus catch the edges of the opening with forceps, if possible, and apply a lateral ligature, or leave the forceps in place for forty-eight hours, or compress firmly with *one* large piece of iodoform gauze.

25. In extramedullary spinal hemorrhage rapidly advancing and threatening life perform a laminectomy and arrest the hemorrhage.

26. In bleeding from a tooth-socket use chlorid of ethyl spray or ice. If this treatment fails, plug with gauze infiltrated with tannin or soaked in antipyrin solution of a strength of 10 per cent., or in Carnot's solution of gelatin, close the jaws upon the plug, and hold them with Barton's bandage. If this expedient fails, soak the plug in Monsel's solution, or plug with a bit of cork or dry sponge, and if this is futile, use the cautery. Pressure on the carotid and ice over the jaw and neck are indicated. It may be necessary to tie the external carotid artery.

27. In intra-abdominal hemorrhage open the belly. In intra-abdominal hemorrhage it is necessary to operate during shock. If the blood accumulates so rapidly as to prevent the location of the bleeding point, compress the aorta or pack the abdominal cavity with large sponges. In seeking for the bleeding-point remove the sponges one by one, or have the pressure momentarily relaxed from time to time. In parenchymatous hemorrhage from the liver try packing with iodoform gauze. If this fails, suture the torn edge or use the cautery. Severe wounds of the spleen demand splenectomy. Wounds of the kidney may be sutured, but may require partial or complete nephrectomy. Mesenteric vessels are ligated *en masse* with silk (Senn). Wounds of the stomach and intestines causing hemorrhage require stitching of their edges. When there are a great many points of bleeding, take a number of sponges, tie a piece of tape firmly to each one, pack many places in the belly with the sponges, bring the tapes out of the wound, and remove the sponges from below upward one at a time, securing the bleeding points as they come into view.

28. In abdominal section for disease of the female pelvic organs bleeding

* Niebergall, Deut. Zeit. f. Chir., vol. xxxvii, Nos. 3 and 4.

is limited by the clamp or by pressure-forceps. Ligation *en masse* is often practised. Use silk. A large mass can be transfixed and tied in sections. Bleeding edges are stitched. Areas of oozing are treated with temporary pressure and hot water, or, if this fails, by the cautery. Packing can be used as a tamponade, which is a gauze pouch, pieces of gauze being packed into this pouch after its insertion into the belly (Fig. 43).

29. A ruptured varicose vein requires a compress, a bandage from the periphery up, and elevation.

30. Most cases of capillary bleeding can be controlled by compression with gauze pads soaked in water at a temperature of 115° to 120° F. This contracts the vessels and seals them with coagulated albumin. Keetly in 1878 impressed the profession with the value of hot water as a styptic. Centuries ago surgeons used hot oil for the same purpose. Capillary bleeding can often be controlled by the application of gauze soaked in Carnot's solution

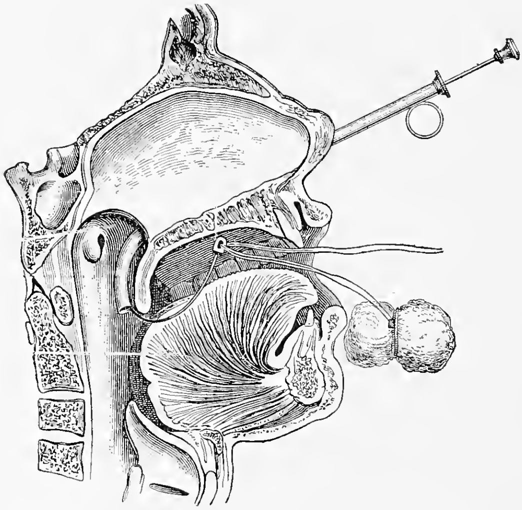


Fig. 174.—Plugging the nares for epistaxis (Guerin).

of gelatin. A solution of suprarenal extract may control capillary oozing. If other means fail to control capillary hemorrhage, the cautery must be used. Understand that the term capillary bleeding does not so much mean bleeding from genuine capillaries as it does bleeding from arterioles and venules.

31. Pressure above a wound arrests arterial hemorrhage, but aggravates venous bleeding. Pressure below a wound arrests venous hemorrhage, but increases arterial bleeding. Remember these facts when applying pressure.

32. A moderate epistaxis may be arrested by an injection of peroxid of hydrogen, an injection of a solution of antipyrin, or an injection of Carnot's solution of salt and gelatin. Favorite domestic expedients are keeping the arms raised above the head and applying ice to the back of the neck. In severe epistaxis, or bleeding from the nose, examine the nose by means of a head-mirror and a speculum. If a little point of ulceration is found, touch it with a hot iron. If the bleeding is a general ooze, if it is high up, or if the cautery does not arrest it, pack the nares. It may be necessary to pack one

nostril or both. Pass a Bellocq cannula (Fig. 174) along the floor of one nostril into the pharynx, project the stem into the mouth, tie a plug of lint or gauze wet with Carnot's solution of salt and gelatin to the stem, and withdraw it. Hold the double string which emerges from the nostril in the hand and pack gauze wet with gelatin solution from before backward. Tie the strings together over the plug; if both nostrils are plugged, the strings from one nostril are fastened to the strings from the other. Do not use subsulphate of iron, as it forms a disgusting, clotty, adherent mass. If a Bellocq cannula is not obtainable, push a soft catheter into the pharynx, catch it with a finger, pull it forward, and tie the plug to it. Remove the plug in two or three days. Do not leave it longer. It blocks up decomposing fluids and may lead to blood-poisoning. Pick out the front plug first, hold the string of the second plug in the hand, push the plug back into the pharynx, catch it with forceps, and withdraw plug and string through the mouth.

33. In gunshot-wounds the primary hemorrhage is slight unless a large vessel is cut. The bleeding may be visible or may be internal (concealed), the blood running into a natural cavity or among the muscles. Capillary oozing is arrested by very hot water and compression. Venous bleeding is usually arrested by compression. If a large vessel is the source of bleeding, enlarge the wound and tie the vessel. If the artery cannot be found in the wound, tie the main trunk.

34. In prolonged bleeding from a leech-bite try compression over a plug saturated with alum or with tannin. If this fails, pass under the wound a harelip pin and encircle it with a piece of silk. If this fails, use the actual cautery or excise the bite and suture the incision.

35. In severe bleeding from the ear elevate the head, put an ice-bag over the mastoid, give opium and acetate of lead, and, if blood runs into the mouth, plug the Eustachian tube with a piece of catheter.

36. Umbilical hemorrhage in infants requires pressure over a plug containing tannin, alum, or gelatin solution. If compression fails, pass harelip pins under the navel and apply a twisted suture. If this fails, use the actual cautery.

37. Rectal bleeding requires elevation of the buttocks, insertion of plugs of ice, ice to the anus and perineum, astringent injections (alum), and the internal use of opium and acetate of lead. If these means fail, plug the bowel over a catheter, or insert and inflate a Peterson bag or a colpeurynter, or tampon and use a T-bandage. If the bleeding persists or if a considerable vessel is bleeding, stretch the sphincter, catch the bowel and draw it down, seize the vessel, and tie it if possible; if not, leave the forceps in place. Failing in this, the actual cautery must be used.

38. Subcutaneous hemorrhage, if severe and persistent, demands that an incision be made and ligatures be applied.

39. Bleeding from a cut urethral meatus requires the insertion of styptic cotton and the application of pressure. Moderate bleeding from the deeper urethra can usually be arrested by a very warm bougie, by very warm injections, or by tying a condom over a catheter, and, after inserting it, inflating the condom by blowing through the catheter and plugging the orifice of the instrument, thus using pressure. Sitting with the perineum on a thickly folded towel is useful. Ice to the perineum does good. The patient can

lie down, have a folded towel applied to the perineum, and a crutch-handle pushed upon the towel, the lower end of the crutch being jammed against the foot of the bed. If a solid bougie has been first introduced, firm pressure can be made by this method. If these means are futile, perform an external urethrotomy and reach the bleeding point.

40. Hemorrhage from the prostate requires hot injections, the introduction of a large bougie first dipped in very warm water, and the retention of a catheter for two days. Perineal section may be required, or suprapubic cystotomy with packing which does not occlude the ureteral orifices.

41. Vesical hemorrhage usually ceases spontaneously, in which case the urine must be drawn off and the viscus be washed out frequently with a solution of boric acid, to prevent septic cystitis. If blood-clots prevent the flow of urine, break them up with a catheter or a lithotrite and inject vinegar and water, a 2 per cent. solution of carbolic acid, or a solution of bicarbonate of sodium. Perfect quiet is to be maintained, cold acid drinks given, ice-bags put to the perineum and hypogastric region, and opium with acetate of lead, or gallic acid to be given by the mouth. If the hemorrhage is severe or persistent, perform a suprapubic cystotomy, wash out the bladder, and, if necessary, plug the bladder with gauze, leaving the ureters uncovered.

42. In hemorrhage after lateral lithotomy, ligate if possible. If the vessel can be caught but cannot be ligated, leave the forceps in place. If it is not possible to catch the vessel with forceps, use a tenaculum. If the tenaculum fails, pass a threaded curved needle through the tissues around the vessel and tie the ligature (suture ligature). Plugs of ice and injections of hot water may be tried. These means failing, pressure is indicated. Take a cannula, fasten to it a chemise (Fig. 175), empty clots from the bladder, insert the instrument into the viscus, and pack gauze between the sides of the cannula and the chemise. The chemise is bulged out and pressure is made. Tie the cannula by means of tapes to a T-bandage. Pressure is thus combined with vesical drainage. Buckstone Brown makes pressure by inflating a rubber bag with air. The hot iron may occasionally be demanded.

Fig. 175.—Cannula à chemise.

43. Renal bleeding requires ice to the loin, tannic acid and opium, gallic acid or sulphuric acid internally, and perfect quiet. The use of a cystoscope will show from which ureter blood is emerging. If the bleeding threatens life and the diseased organ is identified, make a lumbar incision, and suture or perform nephrectomy; if not sure which organ is diseased, perform an exploratory laparotomy.

44. Vaginal hemorrhage requires the ligature or the tampon.

45. Severe uterine hemorrhage (unconnected with pregnancy) requires the tampon. Persistent hemorrhage due to morbid growths may require removal of the tubes and appendages, ligation of the uterine and ovarian arteries, or hysterectomy.

46. Hematemesis, or bleeding from the stomach, is treated by the swallowing of ice, giving tannic acid (dose, 20 or 30 grains) or Monsel's solution (3 drops). Gelatin by the mouth is recommended. Never give tannic acid and Monsel's solution at the same time, as they mix and form ink. Opium is usually ordered. Acetate of lead and opium and gallic acid are favorite remedies, and ergot is used by many. Give no food by the stomach. If life is threatened by bleeding from an ulcer, open the belly and excise the ulcer and suture the wound. If severe hemorrhage follows injury, perform an exploratory laparotomy. Always remember that furicus and even fatal gastro-intestinal hemorrhage may be due to cirrhosis of the liver, and a slight injury may be the exciting cause of such a hemorrhage. In this condition, of course, operation is useless.

47. In bleeding from the small bowel give acetate of lead and opium, sulphuric acid, or Monsel's salt in pill form (3 grains), allow no food for a time, and insist on liquid diet for a considerable period. If hemorrhage threatens life, do a celiotomy and find the cause. If ulcer exists, excise it and suture, or suture a perforation without previously excising. If violent hemorrhage follows injury, explore to discover the cause.

48. In bleeding from the large bowel, use styptic injections (10 grains of alum or 5 grains of bluestone to ℥j of water). If bleeding is low down, use small amounts of the solution; if high up, large amounts. Do not use absorbable poisons. In dangerous cases perform an exploratory operation to find the cause. (For rectal bleeding see 37, p. 391).

49. Hemoptysis or bleeding from the lung, is treated by morphin hypodermatically, by perfect rest, by dry cups or ice over the affected spot if it can be located, and by the administration of gallic acid, which drug aids coagulation.* Of late, nitrite of amyl by inhalation has given good results.

50. In hemorrhage from wound of the lung do not open the chest unless life is threatened. If life is endangered, resect a rib, allow the lung to collapse, and see if this arrests bleeding. If bleeding still continues, remove several ribs, find the bleeding point, ligate or employ forcipressure. A small cavity may be packed with gauze. If a large surface is bleeding, fill the pleural sac with gauze and pack more gauze against the oozing surface.†

Reactionary or Recurrent Hemorrhage (called also Consecutive, Intermediate, or Intercurrent).—This form of hemorrhage comes on during reaction from an accident or an operation—that is, during the first forty-eight hours, but usually within twelve hours. It is bleeding from a vessel or vessels which did not bleed during the shock which accompanied operation, and which vessels were overlooked and not tied. It may be due to faultily applied ligatures. It is favored by vascular excitement or hypertrophied heart. The bleeding is rarely sudden and severe, but is usually a gradual drop or trickle. The Esmarch apparatus is not unusually the cause. The constricting band paralyzes the smaller arteries, which do not bleed during shock and do not contract as shock departs; hence bleeding comes on with reaction. To lessen the danger of the Esmarch apparatus use a broad con-

* The use of ergot is a general but questionable practice. Bartholow and others hold that this drug does harm; it contracts all the arterioles, and hence more blood flows from an area where there is damage. Purgatives do good in bleeding from the lung by taking blood to the abdomen and lowering blood-pressure.

† See author's case, Annals of Surgery, Jan., 1898.

stricting band rather than a rubber tube. After an amputation, when the larger vessels have been tied, gauze pads wet with hot water (115° to 120° F.) should be placed between the flaps. This not only arrests capillary oozing, but stimulates vessels and shows points of bleeding which were not previously visible, and these points are ligated. During reaction after an amputation, if slight hemorrhage occurs, elevate the stump and compress the flaps. If the hemorrhage persists or at any time becomes severe, make pressure on the main artery of the limb, open the flaps, turn out the clots, find the bleeding point, ligate, asepticize, close, drain, and dress. In any severe reactionary hemorrhage open the wound at once and ligate.

Secondary hemorrhage may occur at any time in the period between forty-eight hours after the accident or operation and the complete cicatrization of the wound. Secondary hemorrhage may be due to atheroma, to slipping of a ligature, to inclusion of nerve, fascia, or muscle in the ligature, to sloughing, to erysipelas, to septicemia, to pyemia, to gangrene, and to overaction of the heart. The great majority of cases of secondary hemorrhage are due to infection, and the application of modern surgical principles has rendered secondary bleeding a rare calamity. If during an operation the vessels are found atheromatous, a thread should be passed, by means of a Hagedorn needle, around the vessel, including a cushion of tissue in the loop of the ligature (this prevents cutting through, Fig. 162). Acupressure may be used in such a case. If the surgeon decides to employ the ligature, he must not tie tightly, but must endeavor to approximate the coats rather than to cut them. Two ligatures can be applied or the stay-knot may be used. One great trouble with atheromatous arteries is that their coats cannot contract; another trouble is that the ligature cuts entirely through them. If after an operation the pulse is found to be forcible, rapid, and jerking, give aconite, opium, and low diet. The bleeding may come on suddenly and furiously, but is usually preceded by a bloody stain in wound-fluids which had become free from blood.

Treatment of Secondary Hemorrhage.—Suppose a case of leg-amputation in which, several days after the operation, a little oozing is detected: the treatment is to elevate the stump, apply two compresses over the flaps, and carry a firm bandage up the leg. If the bleeding is profuse or becomes so, make pressure on the main artery, open and tear the flaps apart with the fingers, find the bleeding vessel and tie it, turn out the clots, asepticize, close, drain, and dress. If the bleeding begins at a period when the stump is nearly healed, cut down on the main artery just above the stump and ligate. In secondary hemorrhage from a blood-vessel in nodular tissue, apply a suture-ligature or tie higher up, or, if this fails, amputate. When secondary hemorrhage arises in a sloughing wound apply a tourniquet or an Esmarch bandage, tear the wound open to the bottom with a grooved director, look for the orifice of the vessel, dissect the artery up until a healthy point is reached, cut it across, and tie both ends. If this fails, apply a suture-ligature or use acupressure. In secondary hemorrhage from atheromatous vessels, use the suture-ligature, double ligature with a stay-knot, or employ acupressure.

Secondary hemorrhage may occur after ligation in continuity, the blood usually coming from the distal side. If the dressings are slightly stained with blood, put on a graduated compress. If the bleeding continues or is

severe, make pressure on the main artery of the limb, open the wound and ligate, wrap the part in cotton, elevate, and surround with hot bottles. If this religation is done on the femoral and fails, do not ligate higher up, as gangrene will certainly occur, but amputate at once, above the point of hemorrhage. If dealing with the brachial artery, do not amputate, but ligate higher up and make compression in the wound. In a secondary hemorrhage from the innominate, tie the innominate again and also tie the vertebral.

Operations on the Vascular System.

Paracentesis auriculi, or tapping the heart-cavity, has been suggested for the relief of an overdistended heart from pulmonary congestion. The right auricle can be tapped. Push the aspirator needle directly backward at the right edge of the sternum, in the third interspace. This operation is not recommended, as it is highly dangerous and is of questionable value.

Paracentesis pericardii, or tapping the pericardial sac, is done only when life is endangered by effusion. Introduce the needle two inches to the left of the left edge of the sternum, in the fifth interspace, and push it directly backward (thus avoiding the internal mammary artery). The operation of tapping is extremely dangerous. The heart is lifted up and pushed forward by an effusion and the needle is apt to enter it. The puncture of a ventricle may do no harm, although it is apt to, but the puncture of an auricle is liable to be followed by fatal hemorrhage. It is wiser and safer to expose the pericardium and incise it, as is done for pericardial suppuration.

Operation for Pericardial Effusion or Suppuration.—The operation of tapping should be abandoned in favor of a safer but more radical procedure. There is no spot where we can introduce the needle with perfect safety, and the heart or pleura may be wounded; further, as Brentano shows,* tapping will not completely empty the sac. In a purulent case tapping gives practically no chance of cure. No general anesthetic should be used. A portion of the fifth rib or the cartilage on the fifth rib should be excised, the pericardium exposed and punctured in order to determine the nature of the fluid present. If the fluid is serous, it can be drained away through a small incision, and the pericardium may either be sutured or drained with gauze. If the fluid be purulent, the pericardium should be stitched to the chest-wall and opened. Clots should be removed by irrigation with hot salt solution and a drainage-tube should be introduced.

Operation for Wound of the Heart.—In many cases it is obviously impossible to administer an anesthetic, but when possible it should be given because the movements of the patient while under the knife make operation difficult and increase bleeding. Ether may be used or we may take Hill's advice and give chloroform. Hill would give an anesthetic unless the patient is unconscious and the corneal reflex is abolished. Personally, I would be disposed to use local anesthesia unless the patient's general condition were good or at least fair. The pericardium is exposed freely and Rotter's incision gives excellent access. This exposure is described by Hill in the "Medical Record," November 29, 1902, and was employed in his successful case. Begin an incision over the third rib five-eighths of an inch from the left edge of the sternum and carry it outward along the rib for four inches. Begin an

* Deut. med. Woch., Feb. 11, 1890.

incision over a corresponding point of the sixth rib and carry it out for a like distance. Join the outer extremities of these cuts. Cut through the ribs and pleura with bone forceps and scissors. Raise the flap upon its hinges of cartilages, and have an assistant grasp the lung to prevent collapse. The pericardium thus exposed is opened more widely if necessary. Hill advises us to steady the heart by pressing the hand under it and lifting it. Parrozzani did this by passing a finger through the wound. Other surgeons have used traction sutures of silk. Interrupted sutures are preferred to the continuous suture. Either silk or catgut can be used. They should be inserted with a round-edged needle, and should, if possible, be passed and tied during diastole. "As few as possible should be passed commensurate with safety against leakage, as they cause a degeneration of the muscular fiber" (L. L. Hill, in "Medical Record," Nov. 29, 1902). The pericardial and pleural sacs are cleansed with salt solution. The question of drainage is still *sub judice*. I would be inclined to drain the pericardium with gauze. The pleural sac is treated according to indications in each case.

Operation for Varix of Leg.—Many cases do not require operation. In some, operation is positively harmful. In some selected cases operation is very useful to remove certain complications (ulcer, eczema, etc.), and to relieve the patient from annoyance, but the operation rarely absolutely cures the condition. As Blake points out a cure cannot be claimed until at least one year has passed after operation without reappearance of the varix ("Boston Med. and Surg. Jour.," Sept. 25, 1902). The indications and contraindications are discussed on page 353. Never operate if phlebitis exists, except to treat thrombosis. After any operation for varicose veins of the leg follow Bennett's advice and keep the patient in bed for three weeks and do not let him resume active work for three weeks more ("Lancet," Nov. 22, 1902).

Trendelenburg's Operation.—I have employed this with much satisfaction in cases of varix of the leg following involvement of the saphenous in the thigh. Trendelenburg believes that in varix the valves in the saphenous become incompetent because of high central pressure. The veins of the leg distend, as they are unable to support such a long column of blood, and finally the blood begins to flow in the wrong direction in the saphenous, a "vicious circle" being established. We determine whether a case is a suitable one for Trendelenburg's operation as follows: While the patient is lying down, raise the extremity as though we intended to empty it of blood previous to amputation. After three minutes compress the saphenous vein about the lower third of the thigh by means of a moist gauze bandage, which must not be so tight as to shut off the deeper vessels. Lower the leg and have the patient stand up. If blood flows into the saphenous from above and distends the portion of the vein above the compress, the valves are incompetent and Trendelenburg's operation may be performed. The operation is performed as follows: Make an incision about four inches long over the internal saphenous vein at the junction of the lower and middle thirds of the thigh. Expose the vein, ligate each visible branch, ligate the saphenous at the lower end of the wound and also at the upper end, and remove the portion of vein included between the ligatures. By this operation the central pressure is intercepted and the dilated veins in consequence shrink. Some surgeons have advised the removal of the entire length of the long saphenous vein. If Trendelen-

burg's operation fails and a relapse occurs, extirpate the varicose veins of the leg.

Madelung cuts down over the varices and ligates at various points. *Schede* makes a circular cut (a circumcision) completely around the leg at the junction of the upper and middle thirds, the incision reaching to the deep fascia. All bleeding points are ligated and the edges of the incision are stitched together. *Fergusson* ties the saphenous vein near the femoral and removes a section from it. This makes the varices clearly evident. A semilunar incision is made to surround the varices, which incision reaches to the deep fascia. The flap is raised and dissected up, the vessels are tied, and the flap is sutured in place. The author of this operation claims that it is most satisfactory and certain. *Phelps* advises multiple ligation, which may be described as follows: At several points over the long saphenous vein he makes skin incisions in the long axis of the vessel. Each incision is two inches long. At each point two ligatures are placed one inch apart and the portion of vein between them is removed. Sir Wm. H. Bennett thinks that in ordinary cases the best operation consists in removing a portion of the long saphenous in the thigh and also in removing 3 inches of the vein from below the knee. If there are cystic dilatations above the knee he removes the saphenous from the thigh. Some local varices he dissects out ("Lancet," Nov. 22, 1902).

Open Operation for Varicocele.—The open operation is by far the best procedure for varicocele.

The patient is placed in a recumbent position. He may be given a general anesthetic or Schleich's fluid may be injected. A fold of skin is pinched up on the scrotum, and the surgeon transfixes it in the line of the cord, so that he will have an incision about one and a half inches long running downward from below the external ring. The skin and fascia are cut with a scalpel, the veins are well exposed, and the cord is located and held aside. A double ligature of strong catgut or chromicized gut is passed under the veins by an aneurysm needle. The threads are separated one inch, tied tightly, and the ends are left long. The veins between the ligatures are excised. The two gut ligatures are tied together and cut. This shortens the cord. The scrotum is sewed up with silkworm-gut, a small drainage-tube being used for twenty-four hours.

Bloodgood points out that it is well to avoid dividing the genital branch of the genitocrural nerve which supplies the cremaster muscle. If this nerve should be divided, the cremaster will become lax and return of the varicocele will be favored. Bloodgood makes the incision over the external ring, draws the veins up and resects them. A wound so placed heals more certainly and promptly than does a wound of the scrotum. Of late years I have always followed this plan.

Subcutaneous Ligature for Varicocele.—In this operation employ every antiseptic precaution. The patient stands, and the operator, sitting in front of him, holds the veins in a fold of skin away from the vas deferens by means of the thumb and index-finger of the left hand. A large straight needle carrying a double piece of strong silk is passed entirely through the scrotum, between the veins and the vas. The needle is again inserted at the puncture from which it emerged, is carried around under the skin and in front of the veins, and emerges at its original point of entry. The veins are thus surrounded by the silk. The patient, who now lies down, is placed

under the first stage of ether, and the double ligatures are separated as far as possible from each other, tied, and cut off, the knots slipping in through the puncture. This operation presents certain dangers. The veins may be wounded and the vas or other structures may be included. In an operation it is always best to be able to see what we are doing; and the open operation, being safe, is preferred to the subcutaneous.

Phlebotomy, or Venesection.—The instrument used in venesection is a lancet or bistoury. A fillet or tape, an antiseptic pad, and a bandage are required. A stick should be at hand for the patient to grasp.

Operation.—The patient sits on a chair "with the arm abducted, extended, and inclined outward" (Barker). The parts are asepticized and a tape is tied around the arm just above the elbow. The surgeon stands to the right of the arm, holds the elbow with his left hand, and puts his thumb upon the vein below the intended point of puncture. The patient grasps a stick firmly and works his fingers in order to cause the veins to distend. Either the median cephalic or the median basilic may be opened (Figs. 176, 177). The median basilic is the more distinct, and is the vein usually selected. In opening it do not cut too deep, as nothing but the bicipital fascia separates it from the brachial artery. The median cephalic may be selected (we thus avoid endangering the brachial artery); under this vein lies the external cutaneous nerve (Fig. 177). Steady the vein with the thumb and open it by transfixion, making an oblique cut which divides two-thirds of it. Remove the thumb and allow bleeding to go on, instructing the patient to work his fingers. When faintness begins, remove the fillet, put an antiseptic pad over the puncture, apply a spiral reversed bandage of the hand and arm and a figure-of-eight bandage of the elbow, and place the arm in a sling for several days.

Fig. 176.—Incisions for venesection (Bernard and Huette).

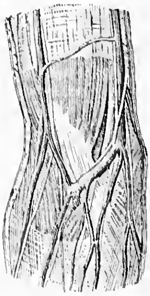


Fig. 177.—Superficial veins in front of elbow (Bernard and Huette).

Transfusion of Blood.—This operation has been a recognized procedure since 1824, though it has been known since 1492, when transfusion was employed in the case of Pope Innocent VIII. Its chief use was in severe hemorrhage, especially post-partum, in which it served to replace the blood lost and supplied something for the heart to contract upon until new blood formed. Senn insists that the operation has proved an absolute failure. It does not prevent death from hemorrhage, and the transferred blood-elements do not retain vitality. Von Bergmann showed that after severe hemorrhage we do not need to inject nutritive elements, but do need to restore the greatly diminished intracardiac and intravascular pressure. At the present day a saline fluid is infused in preference to transfusing blood. In fact, the operation of transfusion has become all but extinct. It exposes the patient to the danger of embolism and infection, its employment requires

material and instruments often difficult to obtain in an emergency, and it has no single element of value beyond that secured by the use of salt solution, except in cases overcome by illuminating gas, in which a more prolonged good effect is produced than by salt solution.

Intravenous infusion of saline fluid is used after severe hemorrhage, in shock, in diabetic coma, in post-operative suppression of urine, and occasionally in sepsis. After a hemorrhage its beneficial effects are often prompt and obvious. This saline fluid increases the arterial tension, gives the heart enough matter to contract upon, and so restores the activity of the circulation, and does not destroy the red corpuscles as plain water would do. We may use a simple apparatus consisting of a rubber tube, a funnel, and an aspirating needle. Some employ an Aveling syringe, and others Collin's apparatus (Fig. 178). The last-named instrument can be used without any danger of air entering with the fluids. Spencer's instrument (Fig. 179) is convenient and useful. Normal salt solution is the fluid usually employed, of a strength of 0.6 per cent. (a heaping teaspoonful of common salt to a quart of warm boiled water). Some surgeons employ an artificial serum which contains 50 grains of chlorid of sodium, 3 grains of chlorid of potassium, 25 grains of sulphate of sodium, 25 grains of carbonate of sodium, and 2 grains of phosphate of sodium in a quart of boiled water. Szumann's solution consists of 6 parts of common salt, 1 part of sodium carbonate, and 1000 parts of water. The following solution is used by Locke and Hare: calcium chlorid, 25 gm.; potassium chlorid, 1 gm.; sodium chlorid, 9 gm.; sterile water sufficient to make 1 liter. One bottle of the commercial fluid when diluted to 1 liter gives a solution of the above composition. The results from artificial serum containing many elements are no better than from normal salt solution. Whatever fluid is used, it should be at a temperature of 105° F. or over as it enters the vein. The stimulant effect of the heat is of great value. The fluid must not be allowed to cool; and a nurse gives constant attention to the temperature of the fluid in the reservoir. This degree of heat will not damage the corpuscles; in fact, Dawbarn has used saline fluid at a temperature of 118° F. without doing damage to corpuscles and with great benefit to the patient. From ½ pint to 2 pints or even more are slowly injected, the condition of the patient determining the amount given. In one case of violent hemorrhage the author used over 2 quarts. In order to infuse this fluid, tie a fillet well above the elbow, and expose by dissection the median basilic vein, or the basilic vein in the portion of its course where it is superficial to the deep fascia. Tie the vein. Incise it above the ligature, insert a fine cannula, and hold the cannula firmly in lumen by tightening a second ligature (Figs. 91, 178). Remove

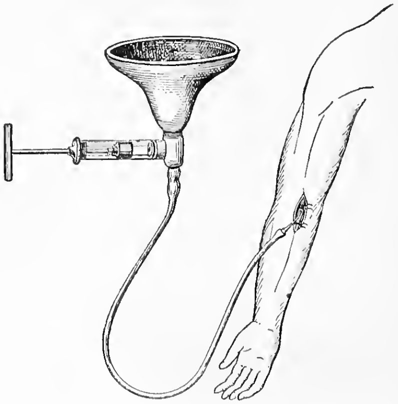


Fig. 178.—Intravenous injection of saline fluid.

the fillet. Slowly and gradually introduce the fluid, carefully watching the pulse. Occupy at least ten minutes in introducing a pint, except in a very desperate case of hemorrhage, when the rapidity of the flow may be accelerated. When the tension of the pulse returns, withdraw the cannula, tie the second ligature tightly, sew up the wound, and dress it aseptically. In very severe operations an assistant should conduct the infusion while the surgeon is operating. It may be necessary to repeat the operation if the circulation fails again. The infusion of a very large amount of saline fluid may do harm. It may embarrass the heart and may lead to edema of the lungs or brain.

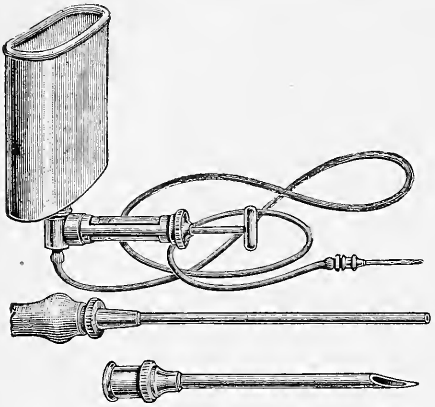


Fig. 179.—Spencer's apparatus for the infusion of saline fluid into a vein. The cannula can be plunged directly into the vessel without preliminary incision.

Arterial Transfusion and Infusion of Saline Fluid in Arteries.—Hueter preferred the arterial method of transfusion, in order to send the blood more gradually to the heart, and thus prevent sudden disturbance of the circulation. A little air in an artery will do no harm, and the danger of venous embolism is avoided. Saline fluid can be infused into an artery. The radial artery is exposed and surrounded by three ligatures, and the thread toward the heart is at once tied. The distal ligature is slightly tightened to cut off anastomotic blood-supply. The artery is cut transversely half through; the syringe is inserted, pointed toward the periphery, and fastened by the third ligature; the second ligature is loosened and the blood is injected. On finishing, the peripheral thread is tied tightly and that portion of the artery which held the cannula is excised. Dawbarn puts a hypodermatic needle into the radial artery and injects saline fluid.

Hemophilia, or Hemorrhagic Diathesis.—The term hemophilia expresses the existence in an individual of a tendency to profuse or even uncontrollable hemorrhage spontaneously or as a result of some very trivial injury.

Hemorrhage may take place from mucous or serous membranes or from wounds of the cutaneous surface, into tissue, into organs, under the scalp, or into the external genitals. In a hemophiliac, if a cut is made, the hemorrhage from the larger vessels is easily arrested, but capillary oozing continues.

The condition is far more common in males than in females, and if it exists in a female, which it rarely does, it is not usually provocative of dangerous hemorrhage. The disease is transmitted by heredity. It is transmitted to a son by a mother, who is usually free from the disease, but whose father had it, and the son bleeds dangerously from slight causes. The existence of the tendency is rarely suspected until the first dentition, and possibly not till puberty; "70 per cent. of cases appear before the fifth year." * The

* R. C. Cabot, in "International Text-book of Surgery."

discovery of the existence of such a condition may not be made until a tooth is pulled, and extraction is followed by persistent bleeding. It is alleged that the tendency may disappear in middle life.

The cause of the condition is unknown. It has been assumed that there is a condition of the blood which prevents coagulation, but the blood of a hemophiliac coagulates outside of the body as well as any other blood. Furthermore, Agnew had a case in which hemophilia was limited to the head and neck, and there have been cases in which the bleeding occurred from one kidney. Some maintain that there is structural defect in the capillaries. In a case of hemophilia in the Jefferson Medical College Hospital in which it was absolutely necessary to amputate a finger because of a crush, a careful study of the vessels of the finger by Dr. Coplin failed to show any disease of the blood-vessels. A surgeon must be on the lookout for this condition, and should inquire for it before deciding to do an operation. If it exists, only an operation of imperative necessity should be undertaken.

A child who is a "bleeder" must be unceasingly watched and guarded. A tendency to profuse oozing exists in leukemia because of the condition of the blood, but this is not hemophilia. A tendency to oozing also exists during jaundice. Eugene Fuller's case of hemophilia ("Med. News," Feb. 28, 1903) was apparently cured by the administration of gr. v of thyroid extract, three times a day. This case is particularly interesting in connection with W. J. Taylor's observation that thyroid extract increases the rapidity of blood coagulation in jaundice cases and lessens the tendency to post-operative oozing in such cases.

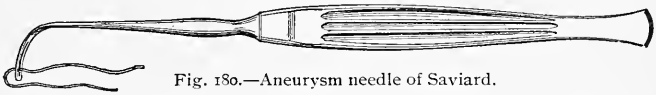


Fig. 180.—Aneurysm needle of Saviard.

Treatment.—The oozing is difficult and often impossible to control. The internal administration of such drugs as ergot, gallic acid, and acetate of lead is useless. It is claimed that chlorid of calcium internally is of service. The local use of astringents is of no avail. Prolonged elevation may in rare cases succeed. In the case in the Jefferson Medical College Hospital the bleeding was arrested, after numerous expedients failed, by compression and hot water. Nurses sat by the bed for several days, constantly compressed the wound with gauze pads soaked in hot water, and changed the pads as soon as they cooled. The local use of Carnot's solution of gelatin has saved several cases from death. It has been advised to take some blood from a healthy man and put it in the cut, in the hope that a firm clot will form.

Ligation of Arteries in Continuity.

The **instruments** used in this operation are two scalpels (one small, one medium), two dissecting forceps, several hemostatic forceps, blunt hooks or broad metal retractors, an Allis dissector, an aneurysm needle, for superficial arteries the instrument of Saviard (Fig. 180), for deep vessels the needle of Dupuytren (Fig. 181), ligatures of catgut, of chromicized gut, or of silk, curved needles and a needle-holder, sutures of silkworm-gut, and the reflector or electric forehead-lamp for deep vessels.

The **position** in which the patient is placed varies according to the vessel to be ligated, though the body is supine except when ligation is to be performed

on the gluteal, sciatic, or popliteal artery. The operator, as a rule, stands upon the affected side, cutting from above downward on the right side, and from below upward on the left side.

Operation.—Accurately determine the *line* of the artery, and make an incision at a slight angle to this line, avoiding subcutaneous veins, and holding the scalpel like a fiddle-bow or a dinner-knife while cutting the superficial parts, and like a pen while incising the deeper parts. On reaching the deep fascia make out the required muscular gap by the eye and finger, so moving the extremity as to bring individual muscles into action. Treves cautions us not to depend upon the yellow line of fat, which often cannot be seen in emaciated people or when an Esmarch bandage is employed; nor upon the white line due to attachment to the fascia of an intermuscular septum. In opening the deep portion of the wound relax the bounding muscles by altering the posture. Open a muscular interspace with a sharp knife, not with a dissector. Make the depths of the wound as long as the superficial incision.

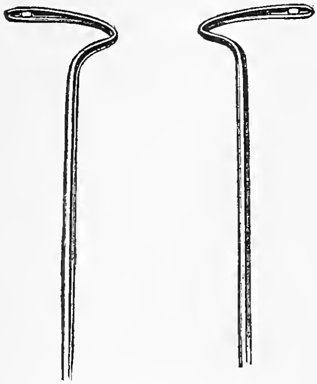


Fig. 181.—Dupuytren's aneurysm needles.

Do not tear structures apart with a grooved director; cut them. Arrest hemorrhage as it occurs. Try to find the situation of the artery with the finger. Pulsation is present, but it may be very feeble and hard to detect. The artery feels like a very thin rubber tube; it is compressible, though not so easily as a vein, and when compressed feels like a flat band which is thinner in the center than at the edges (Treves). A nerve feels like a hard, round cord. The veins are soft, larger than their related arteries, and so very compressible that they can scarcely be felt when pressed upon, and compression causes distal distention. If the wound can be seen into clearly, it will be noted, as Treves asserts, that "the nerves stand out as clear, rounded, white cords; that the veins are of a purple color and of somewhat uneven and wavy contour; that the artery is regular in outline and of a pale-pink or pinkish-yellow tint, the large vessels being of lighter color than the small." Each artery of the upper extremity and each artery below the knee is accompanied by two veins, known as "venæ comites." The arteries of the head and neck, except the lingual, have each a single attending vein; the lingual has venæ comites. Most of the smaller arteries of the trunk (pudic, internal mammary, etc.) have venæ comites. These companion veins may lie on each side of the artery or in front and back of it, and they communicate with one another by transverse branches crossing the artery. On reaching the sheath pick up this structure with toothed forceps so as to make a transverse fold, and thus avoid catching the artery or vein; lift the fold to see that it is free, and open the sheath by cutting toward the edge of the forceps with a scalpel held obliquely with its back toward the vessel, thus making a small longitudinal incision (Pl. 2, Figs. 1, 2). Hold the edge of the incised sheath with the forceps; pass a metal dissector under the vessel and from the forceps; this clears one-half of the vessel. Grasp the other edge of the sheath and pass

the blunt dissector all the way around the vessel. Pass an aneurysm needle under the cleared vessel, away from the forceps holding the sheath and away from the vessel's most dangerous neighbor. Thread the needle and withdraw it. If venæ comites are in the way, try to separate them; but if this proves difficult, include them in the ligature. In small vessels always include them if they are in the way, as this saves trouble. If, in passing the needle, a large vein is severely wounded (such as the femoral), Jacobson advises the employment of digital pressure in the lower portion of the wound while the artery is being tied on a level above or below that of the vein-injury, and after ligation the maintenance of pressure on the wound for a couple of days. A slight puncture in a vein merely requires a lateral ligature. A small wound can be closed with Lembert sutures of fine silk. After getting a ligature under an artery press for a moment upon the artery over the ligature, which is held taut; this pressure will arrest pulsation below if the ligature is around the main artery and there is not a double vessel. Tie the thread at right angles to the vessel with a reef-knot (Fig. 182), rupturing the internal and middle coats. As the ligature is tightened place the extended index-fingers along the ligature up to the artery (Pl. 2, Fig. 3), using the middle joints as the fulcrum of a lever by placing them against each other.

Ballance and Edmunds have recently claimed, as Scarpa and Sir Philip Crampton did long since, that it is not necessary to divide the internal and middle coats to insure obliteration. If this claim be true, the danger of secondary hemorrhage can be greatly lessened. Holmes, however, thinks the older method the more certain of the two. Ballance and Edmunds use floss silk as a ligature material, because it is soft, broad, and flat, and they surround the artery with a double ligature. Ballance and Edmunds thus describe the application of the stay-knot: "The best way of tying two ligatures is to make on each separately, and in the same way, the first hitch of a reef-knot, and to tighten each separately so that the loop lies in contact with the vessel without constricting it. Then taking the ends on one side together in one hand and the two ends on the other side in the other hand, constrict the vessel sufficiently to occlude it, and finally complete the reef-knot. The simplest way of completing the knot is to treat the two ends in each hand as a single thread and to tie as if completing a single reef-knot." This knot is shown in Pl. 2, Figs. 5, 6. The stay-knot applied by this method is of great value if a vessel be atheromatous. Fig. 183 shows an arterial scar after ligation. Fig. 184 shows an intravenous scar.

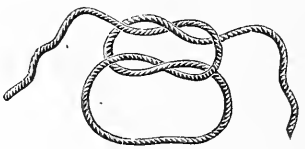


Fig. 182.—Reef-knot.

The chief dangers after ligation are secondary hemorrhage and gangrene. Rigid asepsis usually prevents the first; rest, elevation, and heat antagonize the second.

Radial Artery.—The *line* of the radial artery is from the middle of the front of elbow-joint to the ulnar side of the styloid process of the radius. The *line* in the tabatière is from the apex of the styloid process to the posterior angle of the first interosseous space (Fig. 185).

Anatomy (Pl. 3, Fig. 5).—The radial artery, though smaller than the

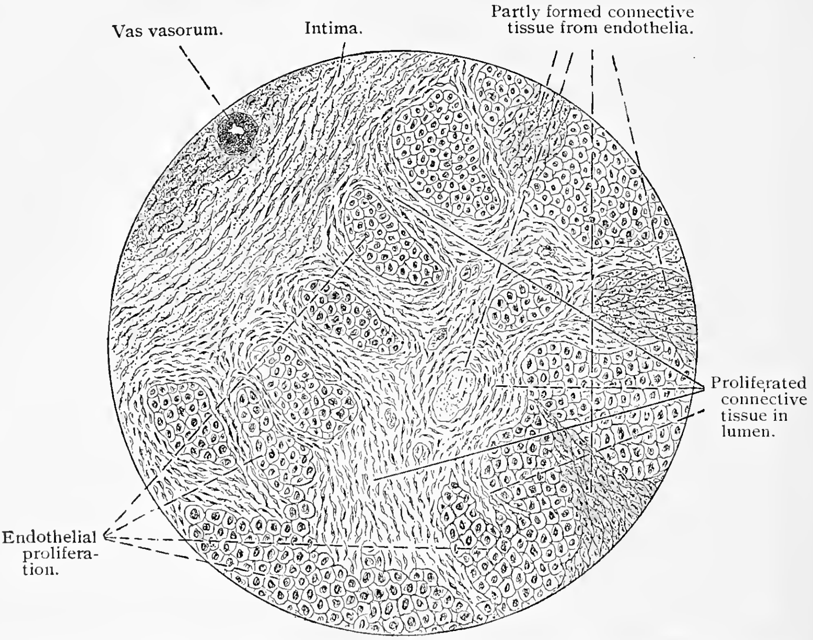


Fig. 183.—Cross-section of obliterated artery, exhibiting the histologic appearances of the intra-vascular scar (× 240) (Senn).

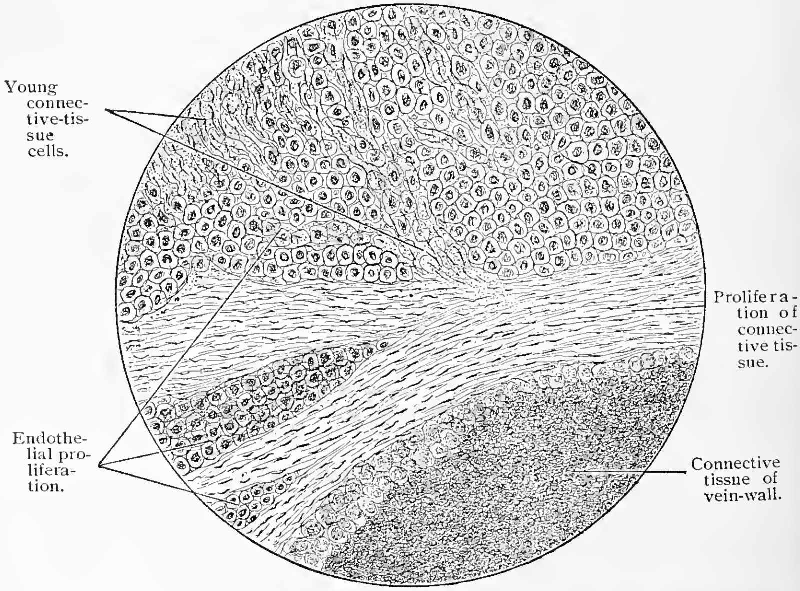
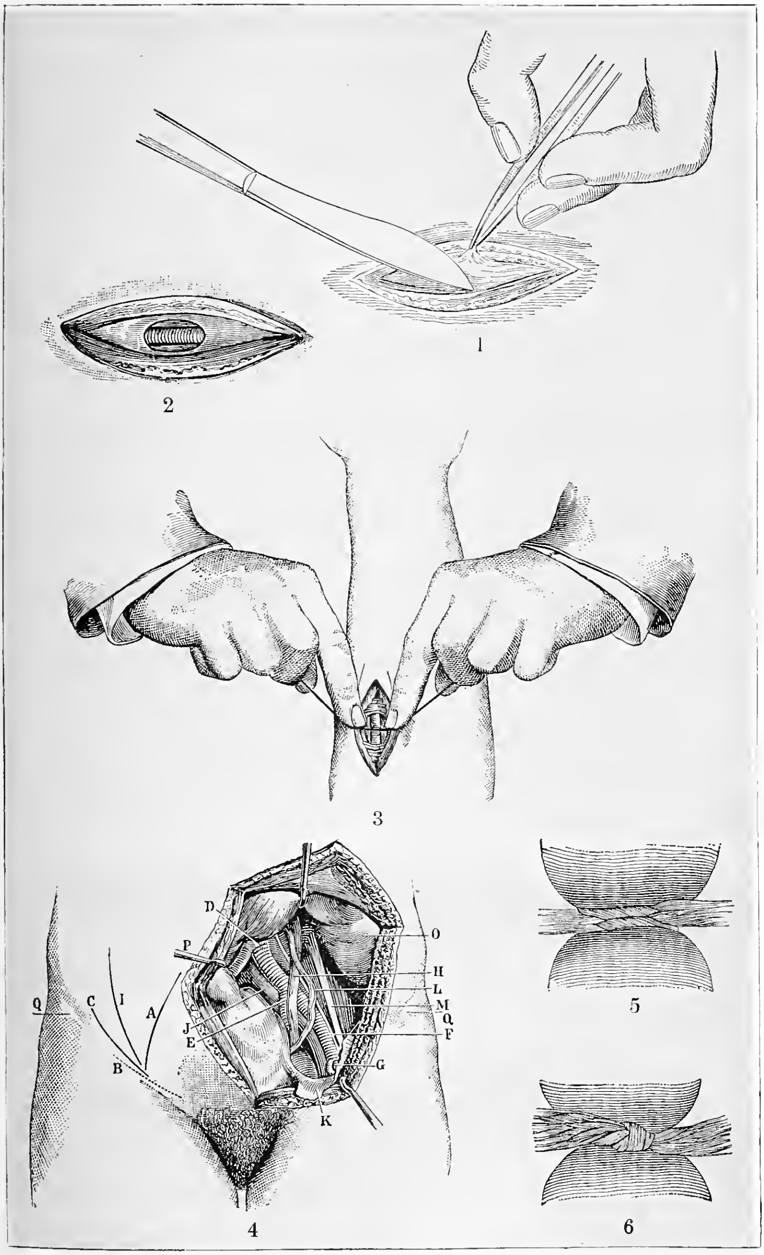


Fig. 184.—Histologic structure of intravenous scar, right internal jugular vein, forty-nine days after ligation. Transverse section between ligatures (× 240) (Senn).



1. Opening the Sheath for Ligation of an Artery (Guerin). 2. Sheath of Artery Open (**Guerin**). 3. Tightening the Knot in Ligation (Guerin). 4. Anatomy of the Iliac Arteries, and showing the lines of incision for their ligation: **1**, Abernethy's incision (Guerin). 5, 6. Ballance and Edmund's Stay-knots.

ulnar, is the direct continuation of the brachial. It arises from the bifurcation of the brachial half an inch below the bend of the elbow, runs down the radial side of the forearm to the front of the styloid process of the radius, passes beneath the extensor muscles of the first metacarpal bone and of the first phalanx of the thumb, and over the carpus to the first interosseous space. It is crossed by the tendon of the extensor secundi internodii pollicis, enters into the palm between the heads of the first dorsal interosseous muscle, and forms the deep palmar arch. The artery in the upper two-thirds of its course is somewhat overlaid by the supinator longus muscle; in the lower one-third of the forearm it is superficial. In the upper third of the forearm it lies between the supinator longus on the outside and the pronator radii teres on the inside; in the lower two-thirds of the forearm it lies between the supinator longus on the outside and the flexor carpi radialis on the inside. Two venæ comites attend the vessel. The radial nerve is to the outer, or radial, side of the artery, well removed from the artery in the upper third, nearer to the artery in the middle third, far external to the artery in the lower third, the nerve at this point passing beneath the supinator longus muscle. The radial artery, from above downward rests upon the biceps tendon, the supinator brevis, the flexor sublimis, the pronator radii teres, the flexor longus pollicis, the pronator quadratus muscles, and the radius. The best guide to the radial artery in the forearm is the outer edge of the flexor carpi radialis muscle or the inner edge of the supinator longus muscle.

The tabatière anatomique of Cloquet, or the anatomical snuff-box, is a triangle whose base is the lower edge of the posterior annular ligament, the ulnar side being formed by the extensor secundi internodii pollicis tendon, the radial side by the extensor ossis metacarpi and the extensor primi internodii pollicis tendons; the floor consists of the trapezium, scaphoid, their dorsal ligaments, and the base of the first metacarpal bone.

Operations.—*Ligation in the tabatière* is a dissecting-room operation of but little practical use. The patient is placed in a recumbent position, the arm is abducted, and the forearm is placed midway between pronation and supination (Barker). The surgeon stands upon the side operated upon. An incision two inches in length is made along the radial border of the extensor secundi internodii pollicis muscle. The skin and superficial fascia are cut and some venous branches are divided. The deep fascia is incised and the vessel is easily found and tied before it passes between the heads of the first dorsal interosseous muscle (Barker).

Ligation of the Lower Third.—In this operation (Pl. 3, Fig. 6, and Fig. 185) the patient is placed supine, the arm is abducted, the forearm is supinated, is rested upon a table, and is held by an assistant. The surgeon stands on the side operated upon, and cuts from above downward on the right forearm and from below upward on the left forearm. The line of the vessel should be determined, and may be indicated with iodin or anilin. An incision one and a half inches long is made at a slight angle to this line and midway between the supinator longus and the flexor carpi radialis muscles, which incision must not extend below the level of the tuberosity of the scaphoid bone. In the superficial fascia watch for the superficial radial vein, and if it comes into view push it aside. Incise the superficial fascia and locate each guide-tendon. Open the deep fascia in the length of the first cut; try to separate the veins,

but if they strongly adhere include them in the ligature. There is no special fascial sheath. The radial nerve will not be seen, but a division of the anterior cutaneous nerve is frequently found in relation with the vessel. The needle can be passed in either direction. A high origin of the superficialis volæ artery is confusing.

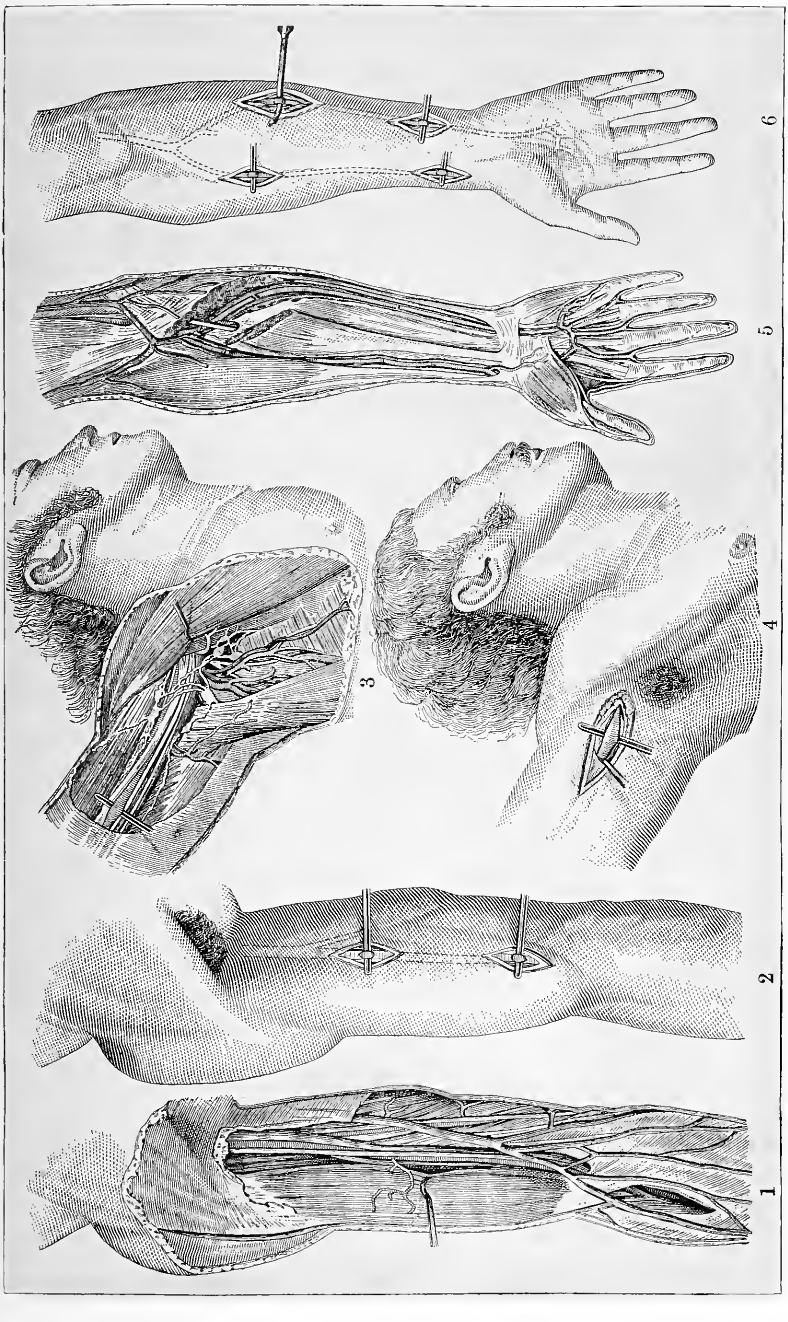
Ligation of the Middle Third.—In this operation the position of the patient should be the same as in the preceding. A two-inch incision is made. Veins of the subcutaneous tissues are avoided. Lying upon the deep fascia is the anterior division of the musculocutaneous nerve. Open the fascia; find the inner edge of the supinator longus muscle and draw it outward, flexing the elbow partly if necessary. Be sure not to cut external to this muscle. Find the vessel where it is bound down by connective tissue to the pronator radii teres muscle, separate the veins, and pass the ligature from without inward. The nerve is external.

Ligation of the Upper Third (Pl. 3, Fig. 6, and Fig. 185).—In this operation the incision is as described above, only higher up. The artery is between the supinator longus and the pronator radii teres, which muscles are at once differentiated by the different direction of their fibers. The artery is usually covered by the supinator longus muscle, which must be retracted externally. The nerve is not seen. The ligature may be passed in either direction.

Ulnar Artery.—No one *line* will overlie the entire ulnar artery. The line of the upper third runs from the middle of the front of the elbow-joint to the point of junction of the upper and middle thirds of the ulna. The line of the lower two-thirds runs from the tip of the internal condyle of the humerus to the radial side of the pisiform bone (Pl. 3, Figs. 5, 6; Fig. 185).

Anatomy (Pl. 3, Fig. 5).—The ulnar artery arises from the brachial bifurcation and runs obliquely inward under the median nerve and a group of muscles from the internal condyle; it turns down the arm, being covered in the middle third of its course by the flexor carpi ulnaris muscle. In the lower third it is superficial, between the tendons of the flexor carpi ulnaris on the inside and the flexor sublimis digitorum on the outside, the vessel being a little overlapped by the flexor carpi ulnaris. This vessel rests first upon the brachialis anticus muscle, next upon the flexor profundus, to which it is bound by a distinct process of fascia, and next upon the annular ligament, which structure it crosses to become the superficial palmar arch. Two venæ comites attend the vessel. In the upper third the nerve is well internal, but in the lower two-thirds the nerve lies near the artery and to its ulnar side. The guide is the outer edge of the flexor carpi ulnaris.

Operations (Pl. 3, Fig. 6, and Fig. 185).—*Ligation of the Lower Third.*—The position in this operation is the same as for ligation of the radial artery. Make a two-inch incision to the radial side of the tendon of the flexor carpi ulnaris, which incision should not be taken lower than a point one inch above the pisiform bone. Avoid the superficial ulnar vein in the subcutaneous tissue. Open the deep fascia, find the tendon of the flexor carpi ulnaris, flex the wrist and draw the tendon inward, open a second layer of fascia, clear the vessel, separate the veins, and pass the ligature from within outward to avoid the nerve. On the artery is the palmar cutaneous branch of the ulnar nerve, and this branch must not be included in the ligature.



1, Anatomy, 2, Ligation, of the Brachial Artery. 3, Anatomy of the Axilla. 4, Ligation of the Third Part of the Axillary Artery. 5, Anatomy, 6, Ligation, of the Radial and Ulnar Arteries. (From Bernard.)

Ligation of the Middle Third (Pl. 3, Fig. 6).—In this operation the position is the same as in the preceding one, the incision being three inches long. Avoid the anterior ulnar vein and the branches of the internal cutaneous nerve in the superficial fascia. Open the deep fascia a little external to the superficial cut (Treves). Find the space between the flexor carpi ulnaris and the superficial flexor, feeling with the index-finger, and when the space is discovered flex the wrist, retract the flexor carpi ulnaris inward and the flexor sublimis digitorum outward, open the fascia, find the ulnar nerve, look external to it for the artery, clear the vessel, separate the venæ comites, and pass the needle from within outward. The ulnar artery should not be ligated in continuity in the upper third of its course.

Brachial Artery.—The *line* of the brachial artery is from the junction of the anterior and middle thirds of the outlet of the axilla, the arm being abducted and the forearm supinated, to the middle of the front of the elbow-joint (Fig. 185).

Anatomy (Pl. 3, Fig. 1).—The brachial artery is the prolongation of the axillary, and extends from the lower edge of the teres major muscle to half an inch below the bend of the elbow, where it divides into the radial and ulnar arteries. It lies first to the inner side of the arm, but passes to the front of the elbow. It is crossed by no muscle, and is, in fact, superficial, barring its being somewhat overlaid in part of its course by the edge of the biceps muscle. The median nerve is external above, crosses over the vessel about the middle of the arm, and reaches the inner side of the artery. The coracobrachialis and biceps muscles are external, and both often overlap the vessel. The ulnar nerve is internal above, and the median nerve is internal below the middle. The basilic vein is to the inner side of the artery, being outside the deep fascia to near the middle of the arm, at which point it pierces it. The artery above is separated from the long head of the triceps by the musculospiral nerve and superior profunda artery and vein; it rests from above down on the inner head of the triceps, the coracobrachialis, and the brachialis anticus muscles. The artery is covered by skin, by superficial fascia, and by deep fascia. The internal cutaneous nerve lies in front of the artery, upon the deep fascia, until it pierces the fascia along with the basilic vein. The artery has venæ comites, and in its upper half has also the basilic vein to its inner side. The guide to the brachial is the inner edge of the biceps muscle. Just in front of the elbow-joint the artery lies in a triangle, the base of which is formed by an imaginary transverse line above the condyles, and the apex by the junction of the pronator radii teres and the supinator longus muscles. The outer line is the supinator longus, the inner line is the pronator radii teres, and the floor is formed by the brachialis anticus and the supinator brevis muscles. From within outward the triangle contains the median nerve, brachial artery, tendon of the biceps, anastomosis of the superior profunda and radial recurrent arteries, and the musculospiral nerve.

Operations.—*Ligation at the Bend of the Elbow.*—In this operation (Pl. 3, Fig. 2, and Fig. 185) the patient is placed supine, the arm is moderately abducted and extended, and is allowed to lie upon its posterior aspect. The forearm is supinated. The surgeon stands upon the side operated upon, and cuts from above downward on the right side and from below upward on the left

side. The tendon of the biceps and the median basilic vein must be accurately located. An incision is made parallel with the inner edge of the biceps tendon and two inches in length, the center of this cut being in the crease of the elbow. On exposing the median basilic vein, retract it downward and inward, open the bicipital fascia, clear the artery of fat, separate the venæ comites, and pass the ligature from within outward to avoid the median nerve. The above operation is not frequently performed.

Ligation in the Middle of the Arm (Fig. 185).—In this operation the patient is placed supine, the arm is abducted, and the forearm is supinated. An assistant holds the forearm, but the arm should not rest upon the table, because, if it be allowed to do so, the inner head of the triceps will be forced forward and may overlie the artery, and thus complicate the operation. Locate the inner edge of the biceps, which is the guide. Make an incision three inches long in the line of the artery. Incise the skin and fascia, flex the elbow slightly, retract the biceps outward, feel for the artery, open the sheath, separate its venæ comites, and, having located the median nerve, pass the ligature from it. In the middle of the arm the nerve is in front of the vessel, above the middle it is external to it, and below the middle it is internal to it. High up the arm the inner edge of the coracobrachialis is the guide, rather than the biceps. Above the middle of the arm the basilic vein is beneath the deep fascia and passes along by the inner side of the artery; hence, high up, the artery has three companion veins, the venæ comites and the basilic vein, and there is seen the ulnar nerve to the inside of the artery.

Axillary Artery.—To determine the *line* of the axillary artery place the arm at a right angle to the body, with the patient supine, and lay down a line from the middle of the clavicle to the humerus near the inner border of the coracobrachialis. The line of the third portion can be approximated by projecting the line of the brachial upward (Fig. 185).

Anatomy (Pl. 3, Fig. 3; Pl. 4, Fig. 1).—The axillary artery is the continuation of the subclavian, and runs from the lower margin of the first rib to the inferior border of the teres major muscle. It is divided into three portions by the pectoralis minor muscle. The first portion is above, the second portion is behind, and the third portion is below, the pectoralis minor. The position of the artery varies with the position of the limb. When the arm is parallel with the body the artery is far from the surface and forms a curve whose convexity is upward and outward. When the arm is at a right angle to the body the vessel is nearer the surface and straight. When the arm is raised above a right angle the artery comes near the surface and forms a curve with the convexity downward.

The first portion of the axillary artery is occasionally ligated. It lies upon the first intercostal muscle and the first serration of the great serratus muscle, and has behind it the posterior thoracic nerve; the brachial plexus is external and posterior to the vessel; on its inner side is the axillary vein; in front of it are the clavicle, the great pectoral muscle, the subclavius muscle, the costocoracoid membrane, the cephalic and acromiothoracic veins, and the external anterior thoracic nerve. The branches of the first part of the axillary artery are the superior thoracic and the acromiothoracic. The second part of the artery is not ligated. The brachial plexus surrounds the second portion. The third part is covered in front, above, by the great pectoral, but is covered

below by skin and fascia; behind, it has the tendon of the subscapularis, the latissimus dorsi, and the teres major muscles; the coracobrachialis is on the outer side; the axillary vein is on the inner side. It is important to remember that there may be three veins, one external and two internal. The axillary vein is formed by the venæ comites of the brachial artery joining, and this new vein effecting a junction with the basilic vein. The median nerve lies upon the axillary artery in the upper part of the third portion of the vessel's course, and passes to the outer side. The musculocutaneous nerve is external, but it is only seen high up; the ulnar nerve is internal; the lesser internal and the internal cutaneous nerves are internal; the musculospiral and the circumflex nerves are behind. The branches of the third portion of the axillary artery are the subscapular and the anterior and posterior circumflex.

Operations.—*Ligation of the Third Portion* (Pl. 3, Fig. 4, and Fig. 185).—The position of the patient should be supine, with the shoulders raised and the arm abducted to a right angle. The surgeon stands between the patient's arm and side, with his back toward the subject's feet. An incision is made three inches in length. It begins half-way up the axilla opposite to the head of the

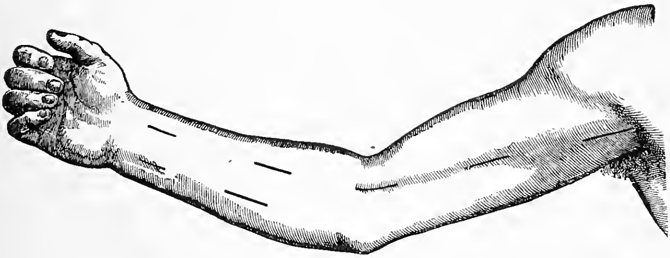


Fig. 185.—Lines of incision for ligation of the axillary (third portion), brachial, radial, and ulnar arteries (MacCormac).

humerus, and is taken downward parallel to the lower edge of the great pectoral muscle and crosses the junction of the anterior and middle thirds of the outlet of the axilla. The integuments and fascia are incised. The vein or veins will be prominent to the inner side and may overlie the vessel. To the inner side with the veins are the ulnar and internal cutaneous nerves. The median nerve is upon, and the external cutaneous is to the outer side of, the artery. Feel for the pulsations of the artery, find the median nerve, and draw it outward, draw the nerves and veins which lie to the inner side inward, clear the artery from the venæ comites, and pass the ligature from within outward. Apply the ligature well below the circumflex branches.

Ligation of the First Part.—This operation (Pl. 4, Fig. 2, and Fig. 187) was first performed in 1815 by Chamberlaine, of Jamaica. The patient is placed supine, the upper part of the body being raised, a sand-pillow being placed between the scapulæ to insure carrying back of the point of the shoulder, and the arm being brought down along the side. In operating on the left side the surgeon stands on the outer side of the left arm; in operating on the right side he stands to the right of the subject's head and leans over his shoulder. The incision, which is

slightly curved downward, begins external to the sternoclavicular joint and ends internal to the margin of the deltoid, thus avoiding the cephalic vein. The incision is half an inch below the clavicle (Fig. 187). Incise the skin, platsyma myoides muscle, and deep fascia. In the outer angle of the wound watch for the acromiothoracic artery and the cephalic vein. Incise the pectoralis major; draw the pectoralis minor downward; retract the lower margin of the wound, cut through the costocoracoid membrane close to the coracoid process and the upper border of the lesser pectoral muscle. Bring the arm to the side so as to relax the structures. Find the brachial plexus, feel for the artery internal to it, clear the vessel, draw the vein internally, and pass the needle from within outward. This avoids the dangerous neighbor, which is the axillary vein. This operation is difficult, dangerous, and unusual, and in its performance the axillary vein, which has a close attachment to the costocoracoid membrane, is apt to be torn.

Subclavian Artery.—The subclavian artery was first successfully tied by Post, of New York, who applied a ligature about the third portion of the vessel in 1817. The first part of the subclavian was first tied by Colles in 1818 (Treves's "Manual of Surgery"). At the present day the first and second portions are rarely ligated. Professor Halsted successfully tied the first portion of the left side for aneurysm. Schumpert tied it successfully for aneurysm. I assisted Dr. Nassau, of St. Joseph's Hospital, Philadelphia, in a ligation of first part of the right subclavian. The man suffered from a ruptured traumatic aneurysm of the third portion of the vessel. The operation was followed by recovery. Chilton produced a cure of an aneurysm of the third portion of the subclavian of the right side by tying the first portion and twenty-four hours later tying the first portion of the axillary. There is no *line* for this vessel.

Anatomy (Pl. 4, Fig. 1).—The subclavian artery of the right side arises from the innominate; that of the left side, from the arch of the aorta. The subclavian is divided into three parts. The first part runs from the origin of the vessel to the inner border of the scalenus anticus muscle; the second part lies behind the scalenus anticus muscle; and the third part runs from the outer edge of the muscle to the lower border of the first rib. The third portion is contained in the subclavian triangle (Fig. 186), and is superficial. It rises, as a rule, to half an inch above the clavicle. The subclavian vein is below the artery, being separated from it by the scalenus anticus muscle. The brachial plexus is above and external to the artery. The vessel rests upon the first rib, and behind it is the scalenus medius muscle. The suprascapular and transversalis colli arteries and veins and branches of the cervical plexus of nerves lie in front of the artery, and the external jugular vein crosses it at its inner side. The third portion gives off no branches.

Ligation of the Third Part.—(See Pl. 4, Fig. 2, and Fig. 187). The patient is placed upon his back, the shoulders are raised, the head is extended and turned toward the opposite side, the arm is pulled down and held by pushing the forearm under the patient's back (Treves). This pulls down the clavicle, thus increasing the size of the subclavian triangle. The operator stands facing the shoulder, with his back toward the patient's feet. The skin over the subclavian triangle, at a point half an inch above the clavicle, is drawn down until it overlies the bone and is incised. This maneuver enables the surgeon

to avoid the external jugular vein and to make an incision in the skin half an inch above the collar-bone. The incision reaches from the anterior edge of the trapezius to the posterior border of the sternocleidomastoid (Pl. 4, Fig. 2, and Fig. 187), and is about three inches long. This incision divides the skin, superficial fascia, the platysma myoides, the vein running from the cephalic to the external jugular, and some superficial nerves. The deep fascia is opened. The external jugular vein is drawn into the inner angle of the wound, and is not divided unnecessarily; if forced to divide the vein, tie with two ligatures and cut between them. The surgeon seeks to find the outer edge of the anterior scalene muscle, and runs the finger down along it to the tubercle on the first rib. The posterior belly of the omohyoid muscle is drawn upward by an assistant. The surgeon, with a finger on the tubercle, recalls the facts that the vein is in front of the finger and the artery is behind it, and that the subclavian vein is on a lower plane than the artery. The artery is felt beating as it lies upon the rib. The artery is cleared and the lower cord of the brachial plexus is exposed. The vein must be guarded with the finger and the needle is passed from above downward, as the plexus, which is in more danger than the vein, is to be avoided. In this operation the transversalis colli and suprascapular arteries must not be cut, as they are necessary to the future anastomotic circulation. If the field of operation is too small, the trapezius or sternocleidomastoid, or both, should be incised transversely.

Results.—According to Joseph D. Bryant, there have been 134 deaths in 250 ligations ("Operative Surgery"). I have twice tied this vessel with success.

The **vertebral artery** was first successfully ligated by Smythe, of New Orleans, in 1864. He had ligated the innominate for aneurysm of the subclavian and at the same time tied the common carotid. Secondary hemorrhage occurred, the blood coming from the brain. He arrested it by tying the vertebral.

Anatomy.—This vessel is the largest branch of the subclavian, and is the first branch coming from the first portion of the subclavian. The vertebral artery ascends and enters the foramen in the transverse process of the sixth cervical vertebra (in rare cases the fifth or the seventh), and ascends through foramina in the cervical vertebræ, passes behind the articular process of the atlas and over the posterior arch of this first vertebra, pierces the posterior occipito-atloid ligament, and enters the skull by way of the foramen magnum (see Gray). It joins its fellow of the opposite side to form the basilar artery. At its point of origin the vertebral artery has in front of it the internal jugular vein and inferior thyroid artery. Gray says that near the spine it lies between the longus colli and scalenus anticus muscles, with the thoracic duct to the left and in front.

Ligation.—The position of the patient is the same as for ligation of the carotid artery. Alexander thus describes the operation: "An incision 3 or 4 inches long is made in an upward and outward direction along the hollow which exists between the scalenus anticus and the sternomastoid muscles. The incision should begin just outside and on a level with the point where the external jugular vein dips over the edge of the sternomastoid muscle, or, if the vein is invisible, about half an inch above the clavicle. The external jugular vein is drawn inward with the sternomastoid muscle. The connective

tissue now appearing, the wound is opened by a blunt dissector, until the scalenus anticus muscle, the phrenic nerve, and the transverse cervical artery are seen. It cannot be too well remembered that the pleura is at the inner side of the wound, while below lies the subclavian artery. It is now only necessary to separate the edges of the scalenus anticus and the longus colli muscles to see the vertebral artery lying in the space between them. The artery is generally completely covered by the vein, which is drawn aside, and the artery is then ligatured" (quoted in Bryant's "Operative Surgery"). When the vessel is cleared and tied, branches of the inferior cervical ganglion are damaged and possibly included in the ligature, and as a consequence the pupil contracts. Jacobson tells us to remember that the phrenic nerve lies on the scalene muscle, the pleura is internal, the internal jugular, inferior thyroid, and vertebral veins are over the vessel, and the thoracic duct on the left side crosses it from within outward.

Results.—In 36 ligations of the vertebral artery there were 3 deaths (Joseph D. Bryant).

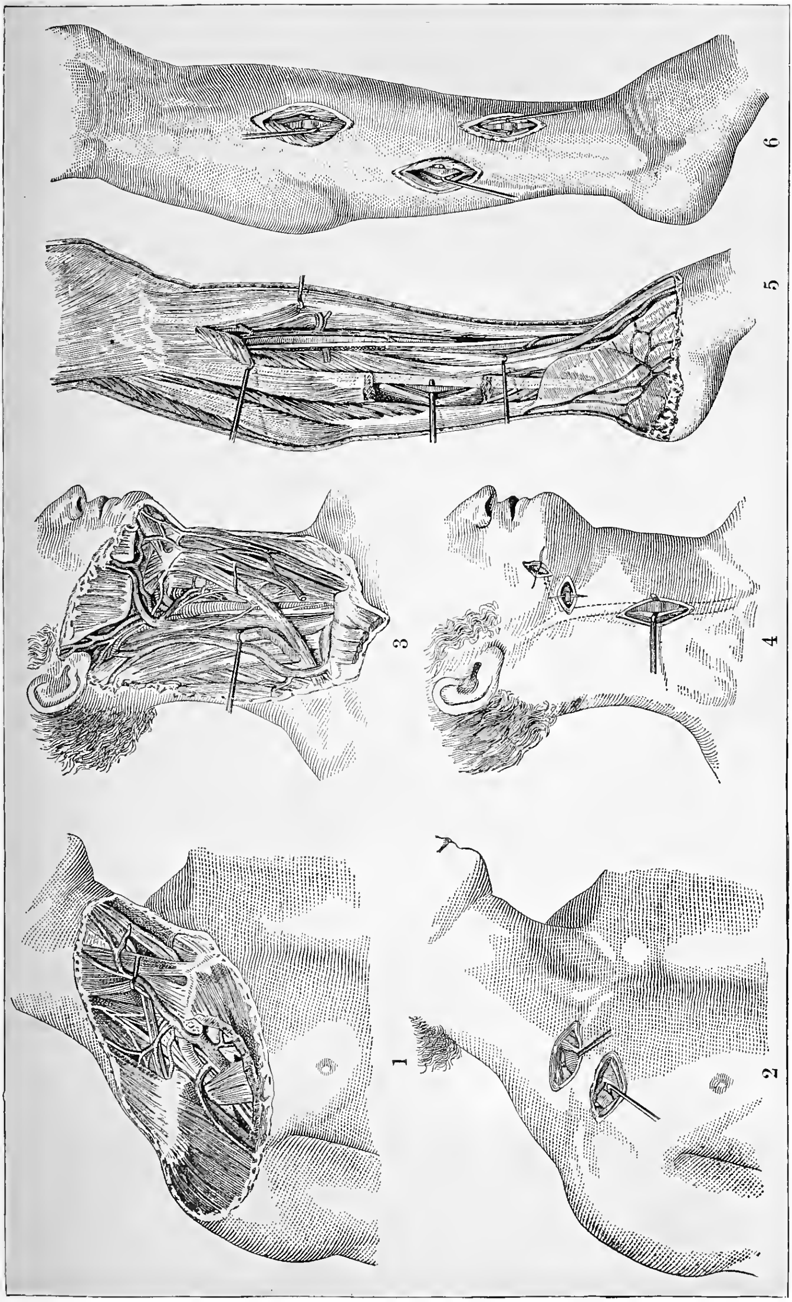
The Inferior Thyroid Artery.—Anatomy.—The inferior thyroid artery is a branch of the thyroid axis. It ascends the neck, passes back of the carotid sheath and the sympathetic nerve, and reaches the thyroid gland. The recurrent laryngeal nerve lies behind the artery. The phrenic nerve is external to the artery and near to it in the first part of its course (up to the point of origin of the ascending cervical branch). The ascending cervical branch takes origin just before the artery begins to dip behind the carotid. In front of the beginning of the inferior thyroid artery of the left side the thoracic duct crosses. The artery is ligated in the second part of its course (between its distribution and the origin of the above-named branch).

Ligation.—The position of patient and the incision are the same as for the ligation of the common carotid artery in the triangle of necessity (page 415). After exposing the sternocleidomastoid muscle retract it outward, and then draw outward the common carotid artery and also the internal jugular vein. The inferior thyroid artery will be found a little below the carotid tubercle. It is cleared and ligated. Treves advises ligation close to the level of the carotid, so as to avoid the recurrent laryngeal nerve.

Innominate Artery.—First successfully ligated by Smythe, of New Orleans, in 1864. It is an extremely fatal operation.

Anatomy.—The innominate artery arises from the beginning of the transverse portion of the arch of the aorta, passes to the back of the right sternoclavicular joint, and divides into the common carotid and subclavian vessels. It rests upon the trachea. It has upon its outer side the pleura, the right innominate vein, and the pneumogastric nerve. Upon its inner side are the remnant of the thymus gland and the beginning of the left carotid artery. In front of it are the inferior thyroid veins of the right side, the left innominate vein, the sternohyoid and sternothyroid muscles, the remnant of the thymus gland, and sometimes a branch from the right pneumogastric nerve.

Ligation.—Place the patient supine, with the shoulders a little raised, and the head thrown back. Carry an incision from the upper margin of the sternum for three inches along the anterior margin of the sternomastoid.



1, Anatomy, 2, Ligation, of the Subclavian Artery and First Part of the Axillary Artery. 3, Anatomy of the Neck. 4, Ligation of the Carotid, Lingual, and Facial Arteries. 5, Anatomy, 6, Ligation, of the Anterior Tibial and Peroneal Arteries. (From Bernard.)

Make another cut of the same length along the upper border of the clavicle to meet the first cut. Dissect up the flap of skin and fascia. Divide the sternal origin and a part of the clavicular portion of the sternocleidomastoid muscle, and cut the sternohyoid and sternothyroid muscles just above their sternal origins (Joseph Bell). Retract the inferior thyroid veins. Divide the dense leaflet of cervical fascia. Find the common carotid artery, and trace back along this vessel until the innominate comes into view. Retract the left innominate vein downward. The needle is passed from without inward to avoid the right innominate vein and right pneumogastric nerve. If the needle is kept close to the artery, the pleura and trachea will not be injured.*

Results.—Three cases have recovered out of 31 reported (Burrell's, Banks's, and Smythe's). Burrell ligated the innominate in 1895 and the patient lived over three months, dying finally from cardiac disease. Mitchell Banks's case lived over three months.

Region of the Neck.—Anatomy.—The side of the neck is that space between the median line in front and the anterior edge of the trapezius muscle behind, which space is limited below by the clavicle and above by the body of the jaw and an imaginary line running from the angle of the jaw to the mastoid process. The sternocleidomastoid muscle divides this space into an anterior and a posterior triangle, and each of the triangles is subdivided by other structures, the anterior into four spaces and the posterior into two (Fig. 186).

Anterior Triangle.—The anterior triangle is bounded in front by the median line of the neck, behind by the anterior margin of the sternocleidomastoid muscle, and above by the body of the lower jaw and an imaginary line drawn from the angle of the jaw to the mastoid process. This space is subdivided into four smaller triangles—namely, the inferior carotid, the superior carotid, the submaxillary, and the submental.

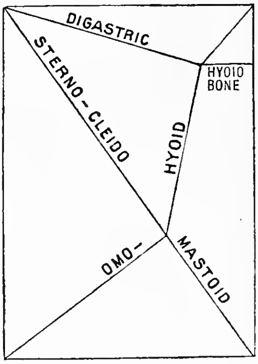


Fig. 186.—The triangles of the neck, right-sided view: 1, Submaxillary triangle; 2, "triangle of election," or superior carotid triangle; 3, submental triangle; 4, "triangle of necessity," or inferior carotid triangle; 5, occipital triangle; 6, subclavian triangle; 7, hyoid bone (after Keen).

The *inferior carotid triangle* is called the "triangle of necessity," because the common carotid artery in this region is ligated, not from choice, but through force of necessity. It is bounded in front by the median line, above by the anterior belly of the omohyoid muscle and the hyoid bone, and below by the anterior edge of the sternomastoid muscle. The floor of this triangle is composed of the longus colli, the scalenus anticus, the rectus capitis anticus major, the sternohyoid, and sternothyroid muscles.

The *superior carotid triangle* is known as the "triangle of election," because, if the carotid artery must be tied, the surgeon, whenever possible, elects or chooses to tie it in this triangle. In this region the carotid is superficial, and there can be tied either the external, the internal, or the common

* See the exceedingly clear and terse account in that excellent book, "A Manual of Surgical Operations," by Joseph Bell.

carotid artery, as may be desired. The triangle is bounded behind by the anterior edge of the sternocleidomastoid, above by the posterior belly of the digastric, and below by the anterior belly of the omohyoid muscles. Its floor is composed of the inferior and middle constrictors of the pharynx and the thyrohyoid and hyoglossus muscles.

The *submaxillary triangle* is bounded above by the body of the jaw and an imaginary line drawn from the angle of the jaw to the mastoid process, behind by the posterior belly of the digastric muscle and the stylohyoid muscle, and in front by the anterior belly of the digastric muscle. Its floor is composed of the mylohyoid and hyoglossus muscles.

The *submental triangle* is bounded on either side by the anterior belly of one digastric muscle; its base is the hyoid bone and its floor is the mylohyoid muscle.

The *posterior triangle* is bounded in front by the posterior border of the sternocleidomastoid muscle, behind by the anterior edge of the trapezius muscle, and below by the clavicle. The posterior belly of the omohyoid muscle subdivides it into two smaller spaces, the occipital and subclavian triangles.

The *occipital triangle* is bounded in front by the posterior edge of the sternocleidomastoid muscle, behind by the anterior border of the trapezius muscle, and below by the posterior belly of the omohyoid muscle.

The *subclavian triangle* is bounded above by the posterior belly of the omohyoid muscle, below by the clavicle, and in front by the posterior border of the sternocleidomastoid muscle. Its floor is formed by the first rib and the first serration of the serratus magnus muscle.

Common Carotid Artery.—The common carotid was tied to arrest bleeding by Abernethy in 1798, and was first ligated successfully for aneurysm by Sir Astley Cooper in 1806. The *line* of the common carotid artery is from the sternoclavicular articulation to midway between the angle of the jaw and the mastoid process, the head being turned toward the opposite side.

Anatomy (Pl. 4, Fig. 3).—The right common carotid arises from the innominate opposite the sternoclavicular joint; the left common carotid arises from the arch of the aorta. In the neck the two carotids possess identical relations. The common carotid runs upward and outward from behind the sternoclavicular articulation to a level with the upper border of the thyroid cartilage, at which point it divides into the external and internal carotid. The common carotid is contained in a sheath derived from the cervical fascia. This sheath also contains, in separate compartments, the internal jugular vein on the outer side of the artery and the pneumogastric nerve between the vein and artery, but more deeply placed. The anterior edge of the sternocleidomastoid muscle lies over the artery and is a guide. Low in the neck the common carotid is deep, being covered by skin, superficial fascia, platysma, deep fascia, and the sternocleidomastoid, sternohyoid, and the sternothyroid muscles. Above the omohyoid muscle the vessel is more superficial, being covered by the skin, superficial fascia, platysma, deep fascia, and the anterior edge of the sternocleidomastoid muscle. Upon the sheath (occasionally within it), above the crossing of the omohyoid muscle, lies the descendens noni nerve—the descending branch of the ninth pair of Willis (the hypoglossal). This nerve is a valuable guide to the sheath in the triangle of election.

The *sternomastoid* branch of the superior thyroid artery crosses the carotid artery a little below its bifurcation, and the superior thyroid vein also crosses it in this region; the middle thyroid vein crosses the artery near its middle, and the anterior jugular vein crosses low down. The common carotid rests upon the longus colli and rectus capitis anticus major muscles, the sympathetic nerve lying between the last-named muscle and the vessel, outside the carotid sheath. The recurrent laryngeal nerve passes behind the carotid below the omohyoid muscle, and the inferior thyroid artery passes behind the carotid just above the omohyoid muscle. The common carotid is in relation internally with the trachea, thyroid gland, larynx, and pharynx. To the outer side are the pneumogastric nerve (which is on a posterior plane) and the internal jugular vein. On the left side, low down in the neck, the jugular vein often lies in front, or partly in front, of the artery.

Ligation in the Triangle of Necessity.—In this operation the patient is placed supine, with the shoulders raised, a sand-pillow under the neck, and the head turned to the opposite side, with the chin raised. The operator stands upon the side operated upon. The incision, three inches long, at a slight angle to the arterial line, runs from the level of the cricoid cartilage downward and inward toward the sternoclavicular joint, following the inner border of the sternocleidomastoid muscle. The surgeon opens the deep fascia, draws the sternocleidomastoid outward, retracts the sternohyoid and sternothyroid muscles inward, and feels for the carotid tubercle of Chassaignac. This tubercle is the costal process of the sixth cervical vertebra, and lies directly under the artery. The tubercle is found about the point at which the omohyoid crosses the carotid. When the tubercle is found we know the situation of the artery, and that the triangle of necessity is below, and the triangle of election above, the tubercle. The operator draws the omohyoid muscle upward, opens the sheath of the artery on its inner side, clears the vessel, and passes the needle from without inward to avoid the internal jugular vein, remembering that the pneumogastric nerve is in the same sheath as the artery and vein, posterior and external to the artery. In this operation the inferior thyroid veins are much in the way, the anterior jugular vein crosses low down, and on the left side, at the root of the neck, the internal jugular vein may be in front of the carotid artery. If the incision is not sufficiently wide, partially divide the sternocleidomastoid or the sternohyoid and thyroid muscles. In the triangle of necessity the descendens noni nerve does not serve as a guide to the sheath of the vessels. (See Pl. 4, Fig. 4.)

Ligation in the Triangle of Election (Fig. 187).—The *position* of the patient for this operation is the same as in the preceding one. An incision, three inches in length, is made along the anterior edge of the sternocleidomastoid muscle in the line of the artery, the middle of this incision being opposite the cricoid cartilage (Fig. 187). In cutting the superficial fascia, the surgeon avoids the external jugular vein, the course of which should be outlined before making the incision. The line of the external jugular is from the angle of the jaw to the middle of the clavicle. The operator opens the deep fascia, retracts the sternocleidomastoid muscle outward, feels for the carotid tubercle, draws the omohyoid muscle downward, finds the descendens noni nerve upon the sheath, opens the sheath at its inner side, and passes the needle from without

inward. This incision permits ligation of either the superior thyroid or the external, internal, or common carotid, and if it be extended up a little there can be tied through it the lingual, and even the facial and occipital, arteries. (See Pl. 4, Fig. 4.)

Results.—In from 20 to 25 per cent. of cases after ligation of the common carotid artery there is cerebral softening or some other intracranial complication. Crile states that of the cases that develop cerebral trouble, one-half die. The operative mortality, according to Crile, is only 3 per cent.

External Carotid Artery.—Burke ligated the external carotid in 1827 (Treves, from Chelius). The *line* of the external carotid artery is the upper portion of the common carotid line.

Anatomy (Pl. 4, Fig. 3).—The external carotid artery, which is one of the terminal branches of the common carotid, arises on a level with the upper border of the thyroid cartilage and runs to the level of the neck of the condyle of the lower jaw. At its point of origin it is covered only by skin, platysma, and fascia, and the edge of the sternomastoid, but as it ascends it passes beneath the digastric and stylohyoid muscles and into the parotid gland. The glossopharyngeal nerve, styloid process, and stylopharyngeus muscle lie between the external and internal carotid arteries. The hypoglossal nerve crosses the vessel just below the digastric muscle, and the facial and lingual veins cross it a little below the nerve. The first branch is the superior thyroid, which arises from the very beginning of the trunk. The lingual arises on a level with the greater cornu of the hyoid bone. The facial and occipital take origin above the lingual. Each of them can be ligated through the incision made for ligation of the external carotid.

Operation.—Place the patient in the same *position* as for ligation of the common carotid. The point of election is between the superior thyroid and the lingual arteries. Make an incision three inches in length at a slight angle to the arterial line, from near the angle of the jaw to opposite the middle of the thyroid cartilage. Cut through the skin, superficial fascia, platysma, and deep fascia, and retract the sternocleidomastoid muscle outward. Watch for the digastric muscle, find the hypoglossal nerve, and feel for the greater cornu of the hyoid bone. Open the sheath a little below the hyoid cornu and pass the needle from without inward. Ligation of the external carotid has been neglected because ligation of the common carotid is easier.

Results.—Crile believes the operative mortality to be 2 per cent.

Internal Carotid Artery.—The internal carotid was tied by Keith, of Aberdeen, in 1851 (Ashhurst's "International Encyclopedia of Surgery"). The *line* of the internal carotid is parallel with and half an inch external to the line of the external carotid.

Anatomy (Pl. 4, Fig. 3).—The internal carotid artery, the other terminal branch of the common carotid, arises on a level with the upper border of the thyroid cartilage and enters the carotid canal. The first inch of the artery is the only point where a ligature is ever applied, this point being covered only by skin, platysma, fascia, and the sternocleidomastoid muscle; higher up it is more deeply placed. It rests upon the vertebræ and the rectus capitis anticus major muscle. The internal jugular vein is in the same sheath and external to the artery; the pneumogastric is in the same sheath, between the artery and the vein, but posterior to both. The superior cervical ganglion

of the sympathetic lies behind the origin of the internal carotid, and between the ganglion and the artery is the superior laryngeal nerve.

Operation.—In this operation the *position* of the patient is the same as for ligation of the external carotid. The incision is of the same length and direction as that for ligation of the external carotid, and is half an inch external. The sternocleidomastoid muscle is drawn outward, the external carotid artery is found and drawn inward, the internal carotid is found and cleared, and the needle is passed from without inward. The internal carotid is known by its more external position and by the fact that it gives off no branches.

Results.—There is the same danger of cerebral complications after this operation as after ligation of the common carotid. The operative mortality is probably as great.

Superior Thyroid Artery (Pl. 4, Fig. 3).—This branches off from the external carotid below the level of the greater cornu of the hyoid bone, in the triangle of election. It is primarily superficial, runs first upward and inward, next downward and forward, passes underneath the omohyoid, sternohyoid, and sternothyroid muscles, and reaches the thyroid gland.

Ligation.—The position of the patient and of the surgeon is the same as for ligation of the carotid. The artery may be reached through the incision employed for ligation of the external carotid. Gross made an incision beginning at the edge of the hyoid bone, and running downward and outward to the sternomastoid muscle. The skin and superficial and deep fasciæ are divided, and the artery is found deeply placed in the triangle of election between the carotid sheath and the thyroid gland.

Lingual Artery.—Charles Bell ligated the first part of the lingual artery in 1814. The operation beneath the hyoglossus muscle was devised by Pirogoff in 1836. (See Treves's "Manual of Operative Surgery.")

Anatomy (Pl. 4, Fig. 3).—The lingual artery arises from the external carotid opposite the greater cornu of the hyoid bone, passes beneath the digastric and stylohyoid muscles, reaches the margin of the hyoglossus muscle, passes under that muscle, and emerges from beneath it to run along the under surface of the tongue. The place of election for ligation is where the artery is beneath the hyoglossus muscle. Its guide is the hypoglossal nerve, which lies upon the muscle, but at a slightly higher level than the artery.

Operation.—In this operation the patient is placed recumbent with the shoulders raised and the face turned away from the side to be operated upon. The surgeon stands upon the affected side. A curved incision is made from a little external to the symphysis of the lower jaw, downward and outward, to just above the greater cornu of the hyoid bone, and upward and outward to just in front of the facial artery at the lower edge of the lower jaw. The skin, the superficial fascia and platysma, and the deep fascia are incised. The submaxillary gland is cleared and retracted well upward. The fascia below the gland is divided by a transverse incision. The posterior edge of the mylohyoid muscle and the bellies of the digastric muscle are sought for and identified. One of the digastric tendons is retracted down and out (Treves). The hyoglossus muscle is cleared with a dissector; the hypoglossal nerve and ranine vein are found and drawn a little upward. The hyoglossus muscle is divided transversely a little above the hyoid bone and

below the level of the hypoglossal nerve. The artery is found under the muscle and the needle is passed from above downward.

Facial Artery.—Anatomy (Pl. 4, Fig. 3).—Arises from the external carotid a little above the lingual, runs upward and forward beneath the body of the inferior maxillary bone, passes along a groove in the posterior and upper surface of the submaxillary gland, crosses the body of the lower jaw at the lower anterior edge of the masseter muscle, and passes forward and upward to the angle of the mouth and side of the nose.

Ligation (Pl. 4, Fig. 4).—The facial artery is rarely ligated in the cervical portion, but may be reached through the incision employed for ligation of the external carotid. The vessel may be tied before it crosses the submaxillary gland, the stylohyoid and digastric muscles being drawn aside. The vessel is reached in the facial portion of its course by a one-inch cut at the anterior edge of the masseter muscle (Fig. 187). Branches of the facial nerve are pushed aside. The needle is passed from behind forward to avoid the vein (Jacobson).

Fig. 187.—Position of the lines of incision of temporal, facial, lingual, common carotid (above the omohyoid), subclavian, axillary (first portion), and internal mammary arteries (MacCormac).

Temporal Artery.—The line of the temporal artery passes "upward over the root of the zygoma, midway between the condyle of the jaw and the tragus" (Jacobson).

Anatomy. — The temporal artery arises from the external carotid behind the condyle of the jaw and in the parotid gland, passes over the zygoma, and divides into two terminal branches.

Ligation.—The patient is placed recumbent and the head is turned to the opposite side. An incision an inch in length is made (Fig. 187), the superficial structures and dense fascia are divided, the vein is retracted backward, and the needle is passed from behind forward.

Occipital Artery.—Takes origin from the posterior surface of the external carotid, below the digastric muscle and opposite the point of origin of the facial artery. It ascends beneath the digastric and stylohyoid muscles and parotid gland; the hypoglossal nerve hooks around it from behind forward. It crosses the internal carotid artery, the internal jugular vein, the pneumogastric and spinal accessory nerves; passes between the mastoid process of the temporal bone and the atlas; grooves the temporal bones; penetrates the trapezius muscle, and ascends over the occiput.

Ligation.—This vessel can be ligated near its origin through the same incision as is employed to reach the external carotid. The hypoglossal nerve is avoided. To tie back of the mastoid process, place the patient in the same position as for ligation of the carotid. Carry an incision from the tip of the mastoid upward and backward, reaching a point midway between the mastoid and the occipital protuberance (Jacobson). Cut the skin, the fascia, the sternocleidomastoid, the splenius capitis, and possibly a portion of the trachelo-mastoid muscles. Bring the head toward the operator in order to relax the structures, retract the edges of the wound, and clear the artery where it lies between the mastoid process and the transverse process of the atlas (Jacobson). An electric forehead light is of great assistance in finding the vessel. Pass the needle away from the vein or veins (there are often several).

Dorsalis Pedis Artery.—The *line* of the dorsalis pedis artery is from the middle of the front of the ankle-joint to the middle of the base of the first interosseous space.

Anatomy (Pl. 5, Fig. 1).—The dorsalis pedis is a continuation of the anterior tibial artery, and it runs from the bend of the ankle to the proximal extremity of the first interosseous space, where it divides into the dorsalis hallucis and the communicating arteries. The artery rests, from above downward, upon the astragalus, scaphoid, and internal cuneiform bones, and at its point of bifurcation lies between the heads of the first dorsal interosseous muscle. It may lie in some persons a little external to this course. It is held upon the bones by a distinct layer derived from the deep fascia. This artery is covered by skin, by superficial and deep fascia, and by the annular ligament above, and is sometimes partly overlaid by the extensor proprius pollicis muscle, and is crossed, just before its bifurcation, by the innermost tendon of the extensor brevis muscle. The inner tendon of the extensor communis digitorum is to the outer side of the vessel; the tendon of the extensor proprius pollicis is to the inner side, and is a guide. The artery is ligated in the dorsal triangle of the foot—a space which is bounded above by the lower edge of the annular ligament, externally by the inner tendon of the extensor brevis, and internally by the tendon of the extensor proprius pollicis. The artery has venæ comites; the anterior tibial nerve lies, as a rule, to its inner side, but may be found upon the artery or to its outer side, and the inner division of the musculocutaneous nerve is external to the vessel in the superficial parts.

Operation (Pl. 5, Fig. 2).—In this operation the patient is placed supine with the leg and foot extended. Heath flexes the leg partly and rests the sole of the foot directly upon the table. The surgeon stands below the extremity, and cuts from above downward. Make an incision two inches in length along the arterial line, beginning opposite the lower edge of the annular ligament and running along by the tendon of the extensor proprius pollicis; cut through the skin and superficial and deep fascia; have the toes extended; retract the tendon of the extensor proprius pollicis inward, and the tendon of the extensor communis digitorum outward; clear the artery, find the nerve, try to separate the venæ comites, and pass the needle from the nerve.

Anterior Tibial Artery.—To locate the *line* of the anterior tibial mark a point midway between the head of the fibula and the tuberosity of the tibia, drop one inch, and draw a line from the second point to the middle of the front of the ankle-joint.

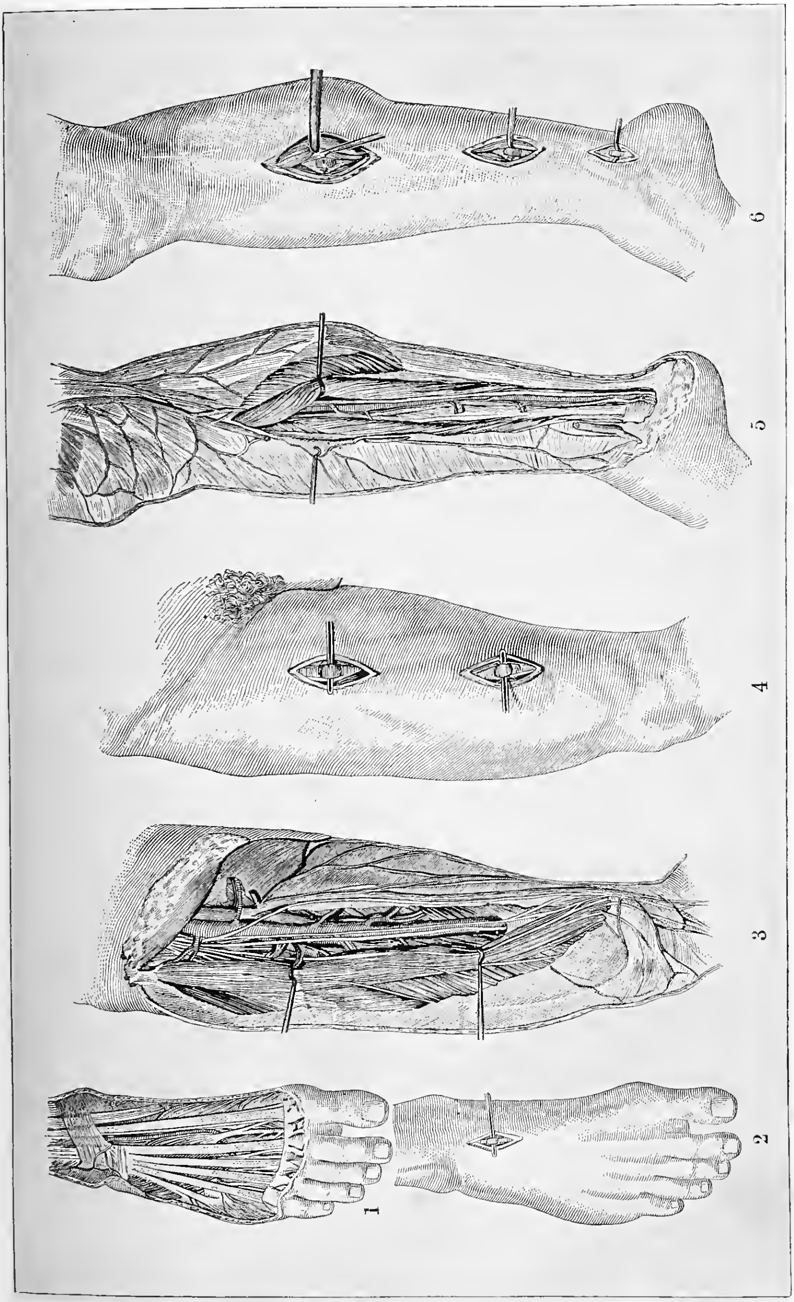
Anatomy.—The anterior tibial artery is one of the terminal branches of the popliteal. It arises opposite the lower border of the popliteus muscle, passes forward between the two heads of the posterior tibial muscle, comes to the front of the leg through an opening in the interosseous membrane, and runs down to the middle of the front of the ankle-joint. In the upper two-thirds of its course it rests upon the interosseous membrane, to which it is fastened by firm fascia; in the lower third it lies first upon the front of the tibia and then upon the anterior ligament of the ankle-joint. For its upper two-thirds the artery has the tibialis anticus muscle just external to it; at the junction of the middle and lower thirds the extensor proprius pollicis comes from the outside and lies either upon the artery or to its inner side for the rest of its course. Externally in its upper third is the extensor communis digitorum; in the middle third is the extensor proprius pollicis; in the lower third, the proprius pollicis having crossed to the inner side, the extensor communis digitorum again becomes the outer boundary. The artery is covered by skin and by superficial and deep fascia. In its upper third it is deeply placed between the muscles; in its middle third it is less overlaid by muscle; in its lower third it is superficial except where it is crossed by the extensor proprius and where it is covered by the annular ligament. The artery has venæ comites. In the lower three-fourths of its course it is accompanied by the anterior tibial nerve, which in its course in the upper third of the leg is external to the artery; in the middle third it is external and a little in front of the artery; and in the lower third it is external to or upon the artery (Pl. 4, Fig. 5).

Operations.—The ligations of the anterior tibial (Pl. 4, Fig. 6) are (1) of the lower third; (2) of the middle third; and (3) of the upper third. In all these ligations the patient is placed recumbent with the leg extended, and the surgeon stands to the outer side of the extremity, cutting from above downward on the right side and from below upward on the left side.

Ligation of the Lower Third.—Make an incision three inches long in the line of the artery and over the annular ligament. This incision is external to the tibialis anticus muscle and half an inch from the outer border of the tibia (Barker). Divide the skin and fascia, retract the tendon of the tibialis anticus inward, and the tendon of the extensor proprius pollicis outward, along with the tendons of the extensor communis. Flex the ankle-joint to relax the tendons, and clear the artery. Draw the nerve external and pass the ligature from without inward. In order to recognize the muscles in this as in other ligations, rely largely upon the finger while the muscles are being moved.

Ligation of the Middle Third.—In this operation the procedure is similar to the above. Remember that the nerve lies in front of the vessel and that the extensor proprius pollicis muscle is external. The nerve is retracted outward and the needle is passed from the nerve. A good rule for detecting the artery is to find the outer edge of the tibia and by this locate the interosseous membrane, and then, by passing out along this membrane, discover the artery.

Ligation of the Upper Third.—Make an incision three inches long in the arterial line. On opening the deep fascia, do not rely on the eye for finding the muscular interspace, as often the latter cannot be seen, and neither a white



1, Anatomy, 2, Ligation, of the Dorsalis Pedis Artery. 3, Anatomy, 4, Ligation, of the Femoral Artery. 5, Anatomy, 6, Ligation, of the Posterior Tibial Artery. (From Bernard.)

nor a yellow line is reliable. Place the index-finger deep in the wound and have the tibialis anticus and extensor communis digitorum muscles successively rendered tense by an assistant. In opening the interspace use the handle of the knife. Relax the muscles, retract the tibialis anticus inward and draw the extensor communis digitorum outward. Find the interosseous membrane where it is attached to the edge of the tibia, and the artery will be found upon this membrane, between the tibia and the nerve. Clear the vessel and pass the ligature from without inward to avoid the nerve.

Posterior Tibial Artery.—The *line* of the posterior tibial is from the middle of the popliteal space to a point midway between the tip of the inner malleolus and the point of the heel (Pl. 5, Figs. 5, 6).

Anatomy.—The posterior tibial is the larger of the two terminal branches of the popliteal. It arises opposite the lower border of the popliteus muscle, passes down between the deep and superficial flexor muscles to midway between the tip of the malleolus and the point of the heel, and divides into the external and internal plantar vessels. In the upper third of its course it is very deeply placed midway between the tibia and fibula; in its middle third it is less deep, having passed inward; and in its lower third it is superficial. At the ankle the artery is beneath the annular ligament. From above downward the posterior tibial artery rests upon the posterior tibial muscle, the flexor longus digitorum muscle, the posterior surface of the tibia, and the internal lateral ligament of the ankle-joint. For the first inch or two of the course of the artery the posterior tibial nerve is to the inner side; the nerve then crosses to the outer side, and remains in that relative position throughout the rest of the course of the artery. When the knee is partly flexed and the leg is laid upon its outer surface the artery is between the operator and the nerve, and the nerve is between the artery and the table. Back of the malleolus, in the first compartment, lies the posterior tibial muscle; in the next compartment is the flexor longus digitorum muscle; in the next compartment are the artery and nerve; and in the most posterior is the flexor longus pollicis muscle.

Operations.—*Ligation Back of the Malleolus.*—In this operation the patient is placed recumbent with the thigh abducted and the leg flexed and resting upon its outer surface. The surgeon stands to the outer side. Make a two-inch semilunar incision corresponding in its curve to the malleolus and half an inch posterior to its margin (Fig. 190). Cut down to the annular ligament, incise the ligament, and find the artery and venæ comites. Clear the vessel and pass the needle from behind forward (to avoid the nerve, which is here posterior and external). Do not make the preliminary incision nearer the malleolus than half an inch, as the sheath of the tibialis posticus muscle will then surely be opened. In closing the wound, suture the ligament by buried sutures of catgut before closing the superficial parts (Pl. 5, Fig. 6).

Ligation in the Middle of the Leg.—In this operation the patient is placed in the same position as for the ligation back of the malleolus. Feel for the inner border of the tibia, and make an incision four inches long one inch behind the osseous border, parallel with it, and extending through skin and superficial and deep fascia (Fig. 190). Draw the gastrocnemius muscle outward. Incise the soleus muscle, but not the fascia beneath the soleus; cut this fascia, after dropping the handle of the knife so that the blade is at right

angles with the plane of the tibia. Clear the artery; pass the needle from without inward (Pl. 5, Fig. 6).

The **popliteal artery** is almost never ligated in continuity. It can be tied at the upper portion of the popliteal space, at the lower portion of the popliteal space, or at the inner side of the thigh.

Anatomy (Fig. 188).—The popliteal artery is the continuation of the femoral, and runs from the opening in the adductor magnus muscle to the lower margin of the popliteus muscle. This vessel runs downward and outward behind the knee-joint and in the popliteal space. The ham, or popliteal space, is a lozenge-shaped space, which above the joint is bounded on the outer side by the biceps muscle, and on the inner side by the semitendinosus, semimembranosus, gracilis, and sartorius muscles, while below the joint it is bounded externally by the plantaris and outer head of the gastrocnemius

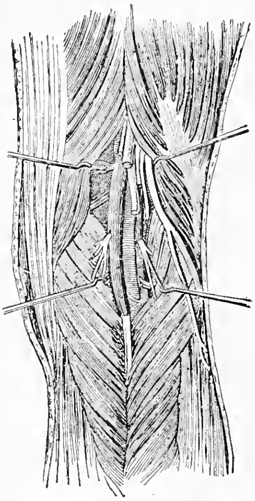


Fig. 188.—Anatomy of popliteal artery (Bernard and Huette).

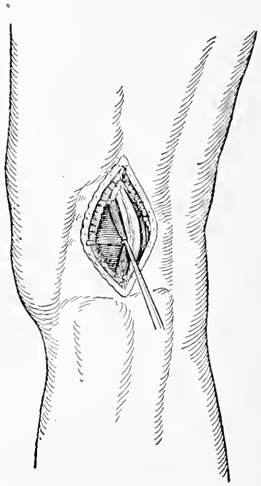


Fig. 189.—Ligation of popliteal artery in its upper third (Bernard and Huette).

muscles, and internally by the inner head of the gastrocnemius muscle. The floor of this space is formed by the surface of the femur, the posterior ligament of the knee-joint, the end of the tibia, and the popliteus fascia. The internal popliteal nerve passes down the middle of the popliteal space; it is superficial to the vessels in the upper half of the space, and is external to them; it is internal to the vessels in the lower half of the space. The external popliteal nerve is in the outer side of the space. The popliteal vein is between the nerve and the artery. Above the knee-joint it is to the outer side of the artery, but below the knee-joint it is to the inner side. The artery lies deeply in the space.

Ligation in Upper Third.—Place the patient prone. The surgeon stands to the outer side of the limb and makes a vertical incision three inches in length along the outer margin of the semimembranosus muscle, exposes the popliteal nerve, retracts the muscle inward and the nerve outward, exposes the artery,

separates it from the other structures, and passes the needle from without inward (Fig. 189).

Ligation in Lower Third.—Make a three-inch vertical incision between the heads of the gastrocnemius muscle. Avoid the external saphenous vein and nerve, and retract them with the popliteal nerve. Separate the artery from the vein and pass the needle from within outward.

Femoral Artery.—The *line* of the femoral artery is from midway between the anterior superior spine of the ilium and the symphysis pubis to the adductor tubercle on the inner condyle of the femur, the thigh being abducted and resting upon its outer surface (Pl. 5, Fig. 3).

Anatomy.—The femoral artery is the continuation of the external iliac trunk; it extends from the lower border of Poupart's ligament to the opening in the adductor magnus muscle, and hence occupies the upper two-thirds of the thigh. The artery for its first five inches is superficial, lying in Scarpa's triangle, a space which is bounded externally by the sartorius muscle and internally by the adductor longus, its base being Poupart's ligament and its floor being composed of the psoas, iliacus, pectineus, and adductor longus muscles, and often the adductor brevis. The artery enters the triangle as the common femoral, but after a two-inch course it divides into the profunda (which passes deeply) and the superficial femoral. The latter vessel is the one alluded to in this section.

At the base of Scarpa's triangle the vein is internal, the artery is between, and the nerve is external (V. A. N.). At the apex of the triangle the vein is internal and a little posterior. At the apex of the triangle the superficial femoral passes under the sartorius muscle and enters into Hunter's canal, which occupies the middle third of the thigh and which terminates at an opening in the adductor magnus muscle. Hunter's canal is bounded externally by the vastus internus muscle, internally by the adductors longus and magnus, and its roof is fascia which stretches from the adductor longus to the vastus internus. In Hunter's canal the vein is behind the artery in the upper part, but external to it in the lower part, and is firmly attached to the artery. There may be two veins. Inside Hunter's canal, but outside the femoral sheath, is the long saphenous nerve, which crosses the artery from without inward.

A way to remember the relation of the femoral vein to the femoral artery is to recall the fact that the relation of the vein to the artery is always contrary to the relation of the sartorius muscle to the artery: when the sartorius muscle is external to the artery, the vein is internal, as at the base of Scarpa's triangle; when the sartorius muscle is crossing in front toward the inside of the artery, the vein is passing at the back to the outside, as at the apex of Scarpa's triangle; when the muscle is over the artery, the vein is back of it, as in the upper third of Hunter's canal; and when the muscle is to the inside of the artery, the vein is to the outside, as in the lower two-thirds of Hunter's canal. In a ligation at the apex of Scarpa's triangle the inner edge of the sartorius is the guide. In a ligation in Hunter's canal the long saphenous nerve is the guide.

Operations.—*Ligation of the Superficial Femoral at the Apex of Scarpa's Triangle.*—In this operation the *position* of the patient is supine with the thigh and leg partly flexed, and the thigh abducted, everted, and rested upon

its outer surface on a pillow. The operator stands to the outer side of the extremity. From a point corresponding to the middle of Scarpa's triangle, and two and a half inches below Poupart's ligament, make a three-inch incision in the arterial line (Fig. 190). Cut the skin and superficial fascia. The saphenous vein will not be seen unless the incision is internal to the arterial line; if this vein is seen, draw it inward. Open the fascia lata, find the inner border of the sartorius muscle, and draw it outward. The fibers of this muscle run downward and inward, thus distinguishing it from the adductor longus, whose fibers run downward and outward. Open the common sheath for the artery and vein, and then incise the individual arterial sheath. Clear the artery and pass the ligature from within outward (Pl. 5, Fig. 4).

Ligation of the Superficial Femoral in Hunter's Canal.—This operation was first performed for aneurysm by John Hunter in 1785. In this operation

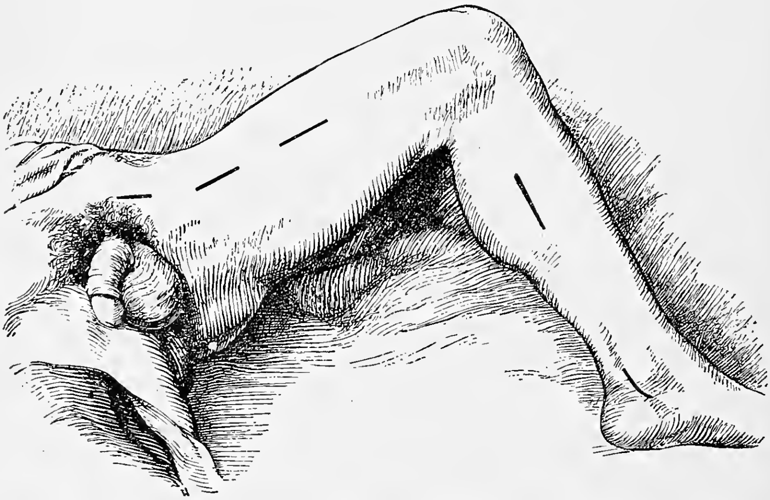


Fig. 190.—The lines indicate the incision to be made for the ligature of the common femoral, of the femoral in Scarpa's triangle and in Hunter's canal, and of the posterior tibial in the calf and behind the malleolus (MacCormac).

the *position* of the patient is the same as in the ligation at the apex of Scarpa's triangle. Make a three-inch incision in the middle third of the thigh, parallel with the arterial line and half an inch internal to it (Barker) (Fig. 190). Incise the skin and superficial fascia, look out for the internal saphenous vein, open the fascia lata, find the sartorius muscle, and retract it inward, thus exposing the roof of Hunter's canal, which is to be opened for an inch or more. Within the canal is seen the long saphenous nerve, usually upon the sheath. Open the sheath of the artery, clear the vessel, and pass the needle from without inward.

Results.—The favorite operation at the present time for popliteal aneurysm is ligation at the apex of Scarpa's triangle. It is a very successful procedure. I have performed it twice with success and have assisted other operators in 3 successful cases. Syme successfully ligated the femoral about its middle twenty-three consecutive times, and in Guy's Hospital the same

operation was done, twenty-four times with 1 death ("Practice of Surgery," by Thomas D. Bryant).

Iliac Arteries.—The *line* of the common and external iliac arteries is from a point half an inch below and half an inch to the left of the umbilicus to midway between the anterior superior spine of the ilium and the pubic symphysis. The upper third of this line represents the common iliac, and the lower two-thirds the external iliac (Pl. 2, Fig. 4).

Anatomy.—The common iliac arteries arise from the aorta opposite the left side and lower border of the fourth lumbar vertebra, and extend to the upper margin of the right and left sacro-iliac joints, where they each bifurcate into an external and an internal iliac. The common iliac arteries lie upon the fifth lumbar vertebra, are covered with peritoneum, and are crossed by the ureters. In women the ovarian arteries cross the common iliacs. Each common iliac vein lies to the right side of its associated artery. The right common iliac artery has in front of it, besides the peritoneum and ureter (in women also the ovarian artery), the ileum, branches of the superior mesenteric artery, and branches of the sympathetic nerve. The left common iliac artery has in front of it, in addition to structures common to both sides (ureter, ovarian artery, sympathetic branches), branches of the inferior mesenteric artery and the sigmoid flexure with its mesocolon. The internal iliac artery runs from the sacro-iliac joint to the upper margin of the great sacrosciatic foramen. It is very rarely ligated (only for gluteal aneurysm, for uncontrollable hemorrhage from the gluteal or sciatic arteries, or to produce atrophy of the prostate gland). The external iliac artery runs from the sacro-iliac joint along the pelvic brim, upon the inner edge of the psoas muscle, to Poupart's ligament. The external iliac vein is internal to the artery. On the right side, high up, it passes behind the artery. The external iliac artery has in front of it peritoneum and subserous tissue (Abernethy's fascia). The ileum crosses the right, and the sigmoid flexure crosses the left, external iliac artery. The genital branch of the genitocrural nerve crosses the artery low down, and the circumflex iliac vein crosses it just before it terminates in the femoral. The spermatic vessels and the vas deferens in the male, and the ovarian vessels in the female, lie upon the artery near its termination. Sometimes the ureter crosses the vessel near its point of origin.

Ligation of the Iliac Arteries after Abdominal Section.—The best method for ligating the common, the external, or the internal iliac is by abdominal section. The patient is placed in the Trendelenburg position. The abdomen is opened in the midline below the umbilicus or in the semilunar line of the diseased side. The intestines are lifted toward the diaphragm, and are held up by gauze pads. The edges of the incision are retracted. The vessel to be tied is located and the point for ligation is selected. The posterior layer of the peritoneum is opened over the selected point, the vessel is cleared, and the threaded Dupuytren's aneurysm needle is passed in a direction away from the vein. In ligating either common iliac, pass the needle from right to left. In ligating the external iliac, pass the ligature from within outward. It is not necessary to suture the posterior layer of peritoneum. The abdomen is closed without a drain. In these operations be sure to push the ureter out of the way. This method of operating is indorsed by Dennis, Hearn, Marmaduke Shield, Mitchell Banks, and others who have employed it.

Results: Bryant ("Operative Surgery") alludes to 5 reported cases of transperitoneal ligation of the common iliac artery with 1 death.

Ligation of the Common Iliac Artery by the Extraperitoneal Method.—The common iliac artery was tied unsuccessfully by Dr. Wm. Gibson in 1812. It was first successfully ligated by Valentine Mott in 1827. The patient is placed recumbent or in the Trendelenburg position. The body is then turned a little to the opposite side and the thighs are partly flexed. Bryant says there are two linear guides for this artery. Crampton's line is drawn from "the apex of the cartilage of the last rib downward and a little forward nearly to the crest of the ilium, then carried forward parallel with it to a little below the anterior superior spine" ("Operative Surgery," by Joseph D. Bryant). McKees' line is "drawn from the tip of the cartilage of the eleventh rib to a point an inch and a half within the anterior superior spine, then curved downward, forward, and inward, and terminating abruptly above the internal abdominal ring" ("Operative Surgery," by Joseph D. Bryant).

The incision can be begun just external to the internal abdominal ring and be curved upward and outward as in ligation of the external iliac, but Crampton's incision gives more room. The superficial tissues are divided down to the transversalis fascia, this structure is nicked and divided, and the exposed and unopened peritoneum is rolled upward and inward. The muscular guide is the inner border of the psoas magnus muscle. By its side an artery is felt. If the sacrovertebral prominence is above the vessel touched, the artery is the external iliac; otherwise it is the common iliac. If the external iliac is the vessel first exposed, follow it up to find the common trunk. When the common iliac is found, separate the fatty tissue about it and pass the ligature from the right toward the left in order to avoid the associated vein.

Results: Jos. D. Bryant tells us that this vessel has been ligated by the extraperitoneal method sixty-nine times with only 16 recoveries, but it is to be remembered that many of these operations were in preantiseptic days.

Ligation of the Internal Iliac Artery.—This operation was first performed by Stevens, of Vera Cruz, in 1812 ("Practice of Surgery," by Thomas Bryant). The incision and the method of exposing the vessel are identical with like steps in the ligation of the common iliac.

Results: Of 26 ligations of this vessel recorded, 18 were fatal, but only a few of the cases were done antiseptically (Joseph D. Bryant's "Operative Surgery").

Ligation of the External Iliac by Abernethy's Extraperitoneal Method (Pl. 2, Fig. 4).—The external iliac artery was first ligated by Abernethy in 1796. The operation failed, but he did the first successful operation in 1806. The patient is placed recumbent with the thighs extended during the first incisions; but in the later stages of the operation the thighs are flexed a little, to relax the abdominal structures. The operator stands to the outer side. The surgeon will find the artery by the side of the psoas muscle. Mark a point one inch above and one inch external to the middle of Poupart's ligament, and another point one inch above and one inch internal to the anterior superior iliac spine (Barker). Join these two points by a curved incision four inches long and convex downward. Cut the skin, the fat, the two oblique muscles, and the transversalis muscle; open the transversalis fascia, separate the peritoneum

toward the vessels, and draw it inward by a broad retractor, and look for the artery along the pelvic brim. The anterior crural nerve is seen to the outer side of the artery, the external iliac vein is to the inner side of the artery, and the genitocrural nerve is upon the artery. Clear the artery near its middle and pass the ligature from within outward. In Sir Astley Cooper's method

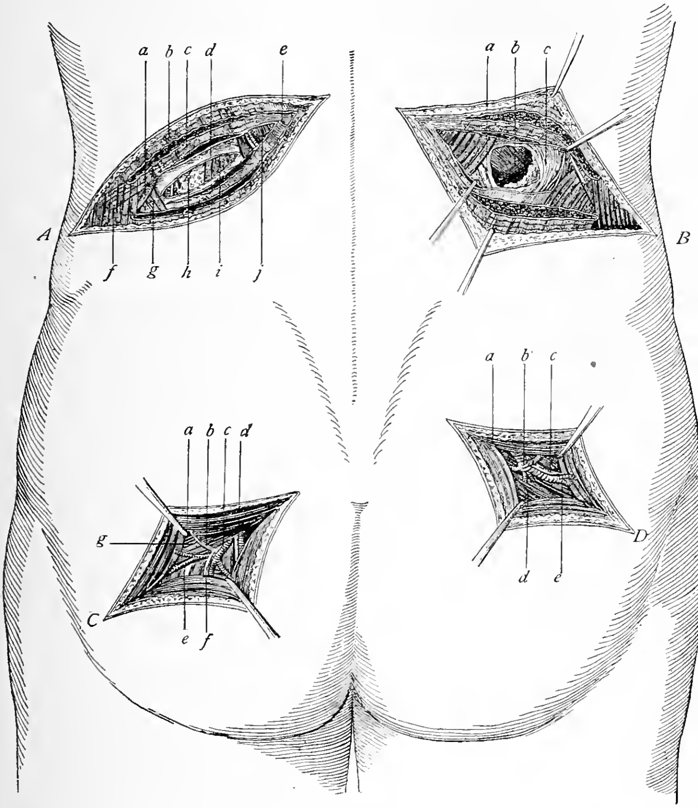


Fig. 191.—*A*, Nephrotomy: *a*, last dorsal n.; *b*, latissimus dorsal m.; *c*, serratus post. inferior m.; *d*, middle layer of lumbar fascia; *e*, outer layer; *f*, ext. oblique m.; *g*, int. oblique m.; *h*, perinephritic (extraperitoneal) fat; *i*, quadratus lumborum m.; *j*, erector spinæ m. *B*, Nephrotomy: *a*, first lumbar n.; *b*, kidney; *c*, transversalis fascia. *C*, Ligature of the sciatic and internal pudic arteries, and exposure of the great sciatic, small sciatic, and internal pudic nerves: *a*, glutæus maximus m.; *b*, inf. gluteal n.; *c*, sciatic a.; *d*, int. pudic a. and n.; *e*, great sciatic n.; *f*, small sciatic n.; *g*, pyriformis m. *D*, Ligature of the gluteal artery and exposure of the superior gluteal nerve: *a*, glutæus maximus m.; *b*, gluteal a.; *c*, superior gluteal n.; *d*, pyriformis m.; *e*, glutæus medius m. (Kocher).

of ligation the inguinal canal is opened; in Abernethy's method the inguinal canal is not opened.

The Gluteal Artery.—This vessel is a continuation of the posterior division of the internal iliac. It emerges from the great sacrosciatic foramen at the upper border of the pyriformis muscle. It rests upon the glutæus minimus, divides into three branches, and is covered by the glutæus maximus muscle. The superior gluteal nerve lies inferior to the artery (Fig. 191).

Ligation.—The patient should be prone. The surgeon stands to the outer side. The incision corresponds to a line drawn from the posterior superior iliac spine to the upper border of the great trochanter (Fig. 192). Divide the skin, fascia, glutæus maximus muscle, and the fascia over the glutæus medius muscle, and retract the glutæus medius upward. Feel for the great sacrosciatic foramen, and at this point the artery is found above the pyriformis muscle. Clear the vessel and pass the needle from below upward (see Kocher's "Operative Surgery"). There is practically no mortality from this operation.

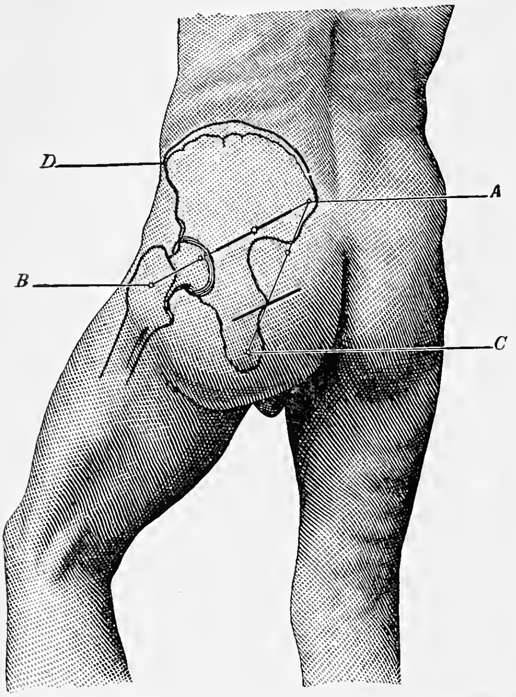


Fig. 192.—Position and direction of the superficial incisions which must be made in order to secure the gluteal artery and the sciatic and pudic arteries: *A*, Posterior superior iliac spine; *B*, great trochanter; *C*, tuberosity of the ischium; *D*, anterior superior iliac spine; *A B*, iliotrochanteric line, divided into thirds. This line corresponds in direction with the fibers of the glutæus maximus muscle. The incision to reach the gluteal artery is indicated by the darker portion of the line. Its center is at the junction of the upper and middle thirds of the iliotrochanteric line, and exactly corresponds with the point of emergence of the gluteal artery from the great sciatic notch. *A C*, ilio-ischiatic line. The incision to reach the sciatic artery and internal pudic is indicated by the lower dark line. It is also to be made in the direction of the fibers of the glutæus maximus muscle. The center of the wound corresponds to the junction of the lower with the middle third of the ilio-ischiatic line (MacCormac).

The Sciatic Artery.—This artery is the larger of the terminal branches of the anterior division of the internal iliac artery. It passes to the lower portion of the great sacrosciatic foramen, lying back of the internal pudic artery, and resting upon the sacral plexus of nerves and pyriformis muscle (Gray). It leaves the pelvis between the pyriformis and coccygeus muscles, and passes downward between the ischial tuberosity and great trochanter. It is covered by the glutæus maximus muscle, rests upon the gemelli, internal obturator and quadratus femoris muscles, has the great sciatic nerve external to it, and the small sciatic nerve external and posterior (Fig. 191).

Ligation.—The patient lies prone. The surgeon stands to the outer side. The incision "corresponds to the middle two-thirds of a line extending from the posterior inferior iliac spine to the base of the great trochanter."* MacCormac advises the incision shown in Fig. 192. Divide the skin, fat, fascia, and the glutæus maximus muscle. Find the artery at the lower border of the pyriformis muscle and trace it to

* Kocher's "Operative Surgery," by Stiles.

its point of emergence from the pelvis. Pass the ligature from without inward. There is practically no mortality from this operation.

Internal Pudic Artery.—This artery is one of the terminal branches of the anterior trunk of the internal iliac. It passes to the lower margin of the great sacrosciatic foramen, and leaves the pelvis between the pyriformis and coccygeus muscles, crosses the ischial spine, and again enters the pelvis by the lesser sacrosciatic foramen. The vessel is accompanied by the internal pudic nerve (Fig. 191).

Ligation.—The position of the patient and the incision are the same as for ligation of the sciatic artery (Fig. 192). The artery is found below the ischial spine. Pass the needle from below upward to avoid the nerve. There is practically no mortality from this operation.

Ligation of the Abdominal Aorta.—This operation was first performed by Sir Astley Cooper in 1817. The patient lived but a few hours. Fifteen cases of ligation of the aorta have been published, and there were 15 deaths, but only 4 of these cases were aseptic operations. The patient of Monteiro, of Rio Janeiro, lived for ten days. The circulation was entirely restored in the limbs, and the man died from hemorrhage resulting from the ulceration produced by a septic ligature. Keen's case lived for forty-eight days after ligation just below the diaphragm. The urinary secretion was plentiful and the circulation in the lower extremities was restored, death resulting from cutting through of the ligature. Robt. T. Morris performed distal ligation below an aneurysm. He encircled the aorta with a soft-rubber catheter and clamped it with forceps. Twenty-two hours after operation the aneurysm began to shrink, and in three hours more had apparently disappeared. Twenty-seven hours after operation the clamp and catheter were removed. The patient died of septicemia fifty-three hours after operation. The necropsy disclosed gangrene of a bit of intestine which had been in contact with the forceps, but the dissecting aneurysm was filled with solid clot, the aorta was patent, and the circulation in the extremities was re-established ("Amer. Jour. of Med. Sciences," Sept., 1900). These cases prove that under certain circumstances the operation is feasible, and in desperate cases it must be considered as a possible means of treatment.

Murray Operation.—This procedure aims to avoid opening the peritoneum. An incision is made from just below the tip of the tenth rib to a point one inch internal to the anterior superior iliac spine. The peritoneum is separated from the abdominal wall until the vessel is reached. Cooper's operation by abdominal section is the preferable procedure.

Operation by Abdominal Section (Cooper's Operation); Instruments Required.—Those used in any ligation, with the addition of an aneurysm needle with a large curve and a very long handle. With an ordinary instrument it is extremely difficult to pass the ligature. It would be a great advantage to use an instrument which, after being passed under the vessel, could have a central eyed shaft projected, as is the center shaft of a Bellocq cannula. Floss silk is probably the best ligature material.

If the patient is much exhausted, an assistant should infuse salt solution in a vein during the operation. In Keen's case there was profound shock, but the moment the ligature was tightened it passed away.

Operation.—The patient should be placed upon his back. The surgeon

stands to the right of the patient and opens the abdomen in the median line, a little above the level of the aneurysm. The intestines are packed aside, the posterior layer of the peritoneum is divided, the surface of the aorta over a small area is cleared of nerves, the plexuses being separated with a blunt dissector.

The needle is passed from right to left. A double ligature of floss silk should be passed and the ends should be tied with a stay-knot. The wound is closed and dressed.

It has been suggested—I think by Wyeth—that it might be wise to only partially tighten the ligature at first, completing the occlusion of the artery after a day or two. Such a procedure would certainly give a better chance for the collaterals to dilate, and restore circulation in the legs.

Unfortunately, in an aneurysm, the vessel will usually be extensively diseased, and ligation will be out of the question. If, however, a normal region is found, the chance of success in a case of aneurysm will be greater than in a case of hemorrhage from a branch of the aorta, because, in a case of aneurysm, the probabilities are that the collaterals are somewhat distended before a ligature is applied.

XIX. DISEASES AND INJURIES OF BONES AND JOINTS.

Diseases of the Bones.

Atrophy of bone is a diminution in the amount of bony matter without change in osseous structure. It arises from want of use (as seen in the wasting of the bone of a stump) or from pressure (as seen in the destruction of the sternum by an aneurysm of the aorta). *Eccentric* atrophy is the thinning of a long bone from within, the outer surface being unchanged. It is usually a senile change. *Concentric* atrophy means a thinning of the outer surface of the shaft, causing a lessened diameter. It is usually linked with eccentric atrophy.

Hypertrophy of bone may be due to increased blood-supply (as is seen in chronic epiphyseal inflammation), the bone growing much more than does its fellow. It may arise from excessive use or from strain, as is seen in the increased size of the fibula when the tibia is congenitally absent.

Tumors of Bone.—Bones give origin to both innocent and malignant tumors. Myeloid sarcoma takes origin in the endosteum and expands the bone. The fasciculated sarcoma is a periosteal growth. Besides these growths there may develop an osteoma, a chondroma, and secondary deposits of cancer and sarcoma. There is no such thing as primary cancer of bone. A bone may become cystic, and occasionally the cysts are due to hydatids. Gummata are frequently met with.

Cysts and Cystomata of Bone.—The majority of bone-cysts are produced by softening of solid neoplasms (sarcoma, myxoma, chondroma). Occasionally "cysts from softening arise in osteomalacia and osteitis deformans" ("An American Text-Book of Pathology"). Hydatid cysts and dermoid cysts are sometimes encountered. A true cystoma of bone, except in one of the jaws, is a surgical rarity. In the maxillary bones dentigerous cysts or cystomata are not very uncommon.

Actinomycosis of bone is most usual in the jaw, but may attack the orbit, ribs, sternum, or limbs (see page 272). Actinomycosis of bone may arise secondarily after infection of superficial parts with the ray-fungus. In the jaw the fungus obtains entrance to the interior of the bone through a tooth socket. In some cases of bony actinomycosis the fungus reaches the bone by the blood. Actinomycosis leads to the production of granulation tissue, the bone is expanded and becomes carious, and a quantity of new bone is sometimes produced. In vertebral actinomycosis, although the condition resembles tuberculosis, angular deformity does not occur.

Tuberculosis of bone tends especially to appear in the cancellous ends of long bones; a tuberculous area is apt to caseate and destroy large amounts of bone. The bone does not sclerose, but undergoes alterations of an osteoporotic nature (see page 232).

Osteitis, Periostitis, and Osteoperiostitis.—Osteitis, or **inflammation of bone,** may be due to traumatism, to a constitutional malady or diathesis, to the extension of inflammation from some other structure, or to infection. In inflammation of bone the exudate and leukocytes pass into the Haversian canals, spaces, and canaliculi. The bone-corpuscles proliferate and the bone undergoes thinning (rarefaction), not because of pressure,

but because of absorption by voracious leukocytes and osteoclasts. This process of rarefaction enlarges all the bony spaces, and by destroying septa throws many of the spaces into one. If the surface of a bone inflames, the periosteum will be separated more or less by the exudation, and the bone will be covered with little pits or erosions made by the leukocytes. Inflamed bone is so soft that it can readily be cut with a knife.

Osteitis may terminate in *resolution* or it may terminate in *sclerosis*, the mass of proliferating cells being converted first into fibrous tissue and next into dense bone which contains very few small cancellous spaces. If the exudation is under the periosteum, the bone will be thickened at this point, bone stalactites marking the points of passage of the vessels. Osteitis may terminate in *suppuration*, this condition being often called *caries*. In tuberculous osteitis caseation of the inflammatory products is very apt to arise (tuberculous or strumous caries). Acute osteitis may terminate in *necrosis*, the inflammatory exudate compressing the vessels in their bony canals, a portion of the bone being in consequence deprived of nutritive material. The portion cut off from nutritive fluid dies *en masse* (necrosis). Osteitis is usually associated with more or less periostitis. A simple acute periostitis without involvement of the bone may arise from traumatism or strain; but in all severe cases of periostitis, in all chronic cases, in all cases due to syphilis, rheumatism, measles, scarlatina, or enteric fever the bone is involved at the same time or subsequently. In syphilitic states gummatous degeneration frequently ensues.

Symptoms of Osteitis and Osteoperiostitis.—As a chronic process, *osteitis* is most commonly found in the femur. Its history usually exhibits a record of an antecedent injury or chilling of the body. Pain is severe, boring or aching in character, deep-seated, worse at night, and aggravated by a dependent position of the part. The symptoms closely resemble those of periostitis, with which disease it is almost sure to be linked. Tenderness exists on percussion, and sometimes on pressure. Subperiosteal swelling, fusiform in shape, is noted; cutaneous edema and discoloration are observed if a superficial bone is inflamed. In syphilis, atrophic osteitis may attack the cranial bones and produce softening or even perforation, or osteophytic osteitis may arise, exostoses being formed. *Osteoperiostitis* may be acute or chronic, circumscribed, or diffused, and may terminate in resolution, organization, or suppuration. It arises from cold, blows, wounds, strains, the spread of adjacent inflammation, specific febrile maladies, pyogenic infection, syphilis, rheumatism, or tuberculosis. The symptoms are pain (which is worse at night and which is aggravated by motion, pressure, or a dependent position), swelling, edema, and discoloration of the soft parts. Pain in the syphilitic form is not so severe as in other varieties. *Acute necrosis* or *diffuse periostitis*, a septic inflammation of bone and periosteum, is commonest in boys about the age of puberty. It is usually due to cold, a specific fever, or injury, and most often affects the tibia or femur; the symptoms locally are redness, swelling, and severe pain; constitutionally there are rigors, fever, and sometimes convulsions. Necrosis is apt to result. Pyemia is common. In *simple acute periostitis* a swelling is felt upon the osseous surface. The swelling is firmly fixed and is very tender but the bone itself is

not enlarged. There is some local heat, discoloration, often fever, and the patient complains of an aching pain, which is worse at night.

Periostitis due to strain demands some special attention. Sir James Paget, years ago, pointed out that muscular exertion might cause periostitis. C. T. Dent has written a valuable article upon this subject.*

It is common to hear football players complain of some swelling of the knee-joint. Examination finds tenderness over the tubercle of the tibia with slight swelling of the joint. Dent points out that pain is felt on straightening the leg, not on rotating it. The same observer states that omnibus drivers suffer from periostitis of the fibula, due to pressing forcibly against the foot-board; those who ride may develop periostitis of the adductor insertion (riders' bone); the victims of flat-foot may labor under periostitis of the inner tuberosity of the os calcis; bar-keepers, from working a beer-pump, may get periostitis of the scapula, pain being marked on contracting the biceps; a housemaid may develop periostitis at the points of bony origin of the great pectoral from the chest, the condition being due to sweeping and scrubbing.†

Treatment of Osteitis and Osteoperiostitis.—In syphilitic forms the local treatment consists in rest, elevation of the part, the application of iodin and mercurial ointment, and bandaging. Specific treatment is by the stomach or hypodermatically. Operation is rarely justifiable. In other forms, if the case be recent and severe, put the patient to bed, place the limb in a splint and elevate it, employ cold, apply a bandage, and give salines and iodid of potassium internally. Later use ichthyol inunctions locally and apply a hot water-bag. Morphin is administered for pain. If these means fail, order counterirritation by iodin and blue ointment or blisters, and apply heat locally. In severe cases take a tenotome and slit the periosteum subcutaneously to relieve tension; this procedure often quickly relieves the pain. Some cases demand a longitudinal osteotomy, which is performed by taking Hey's saw and dividing the bone longitudinally into the medullary canal. If pus forms, drain at once.

Diffuse osteoperiostitis requires early and free incisions, antiseptic irrigation, drainage, rest and elevation of the limb, and strong supporting and stimulating treatment. Amputation is sometimes demanded, as when the patient grows weaker and weaker even after incision, and when a joint is seriously involved. If the necrosis affects the entire shaft, which separates from its epiphyses, and new bone has not yet formed from the periosteum, make a subperiosteal resection of the shaft.

Chronic periostitis is usually syphilitic. A *node* is a chronic inflammation of the deep periosteal layers. Nodes occurring early in the secondary stage remain soft and soon pass away under treatment, but those occurring two years or more after infection are apt to cause a bony deposit. A node may soften, leaving a sinus, at the bottom of which is a piece of dead bone. Gumma of the periosteum is one form of node which is apt to produce caries or necrosis.

Osteoplastic periostitis accompanies chronic osteitis and causes the deposit of new bone, which undergoes sclerosis. The chief *symptom* is aching pain, which is worse when the patient is warm in bed, and is aggravated by damp and wet. A swelling is found at the seat of pain (often over the tibia

* Practitioner, Oct., 1897. † Ibid.

ulna, clavicle, or sternum). The soft parts are uninflamed and move freely unless softening or suppuration has occurred. Tenderness is manifest.

Treatment of Chronic Periostitis and Osteoplastic Periostitis.—For the nodes of early syphilis administer mercury by the plan usually followed in secondary syphilis; for the nodes of late syphilis give mercury and large advancing doses of iodid of potassium. Blisters, blue ointment, and iodin are applied to the skin over the area of periostitis in both forms, and subcutaneous division of the periosteum is of value. If suppuration occurs, incise antiseptically.

Chronic Abscess of Bone, or Brodie's Abscess.—This condition is sometimes due primarily to tuberculous infection, symptoms being absent for a longer or shorter time and arising because of secondary infection with staphylococci. It is always chronic, never acute. A very acute inflammation, such as is induced by virulent pyogenic organisms, causes acute necrosis rather than an acute abscess. After typhoid fever an area of suppuration may slowly form in the head of a long bone, due to the action of typhoid bacilli. Non-virulent staphylococci may be responsible, and the condition may follow long after a staphylococcus osteomyelitis, and in 84 per cent. of cases of Brodie's abscess this is the history (Alexis Thomson). The same author says the latest period between the osteomyelitis and the abscess varies from one to fifty-seven years. Chronic abscess of bone was first described by Sir Benjamin Brodie, and is often called *Brodie's abscess.* It occurs in the cancellous structure of the ends of bones—usually in the head of the tibia, sometimes in the femur (Fig. 193) or humerus. It seldom occurs in the shaft of a long bone. A tuberculous abscess of bone may follow a slight injury, which constitutes a point of least resistance. Bacteria lodge and multiply; bone rarefaction leads to the formation of a cavity, the inflammatory products caseate, sometimes suppuration arises, and the surrounding bone thickens and hardens because of growth from the periosteum. The abscess is apt to break and often breaks into a joint, as the joint-surface is not covered by periosteum and no barrier of bone is there formed. Brodie's abscess may induce necrosis.

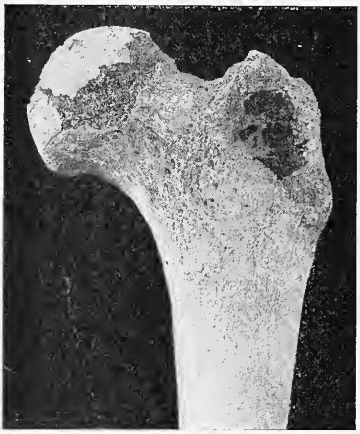


Fig. 193.—Chronic abscess in the great trochanter ("American Text-Book of Surgery").

Alexis Thomson thus describes Brodie's abscess ("Edinburg Med. Jour.," April, 1906).

In the first or quiescent stage there is a cavity filled with serum and lined with a membrane like the periosteum of young bones. The outer layer of the membrane is forming new bone of a spongy nature, "further away the old bone is sclerosed and the medullary canal obliterated."

When the mature stage or abscess stage arises the lining membrane is converted into granulation-tissue, and the cavity becomes filled with staphylococcus pus. The outer layer of granulations erodes the bone and the abscess progressively enlarges. As the bone is eroded within, new bone is formed

by the periosteum and the bone enlarges. If pus formation is more rapid than bone erosion there is tension and pain, but if bone erosion is sufficiently rapid to prevent tension there is little or no pain. Finally the abscess perforates the bony shell "on the periosteal surface or into an adjacent joint."

Symptoms.—There are attacks of boring pain, worse at night and aggrevated by motion and pressure, and a dependent position. The pain is intermittent and may be absent, for many days at a time. These pains are frequently thought to be rheumatic. The tenderness is marked, even when pain is absent, and is not in the joint, as the patient believed the pain was, but is over the abscess. If the head of the tibia or the great trochanter is the seat of disease percussion over that region develops pain most certainly. At times pain in the bone becomes excruciating and tenderness acute. There is more or less loss of function in the limb and in far advanced cases the bone is enlarged. There may be thickening of the bone and soft parts, edema and discoloration of the skin over the seat of trouble, and attack after attack of synovitis in the nearest joint. Irregular fever and sweats are usually noted but there may be no fever. The harrassing pain causes sleeplessness, exhaustion, and emaciation. When the pus breaks through the bone abscess develops in the soft part, and if this bursts or is opened pain ceases (Thomson). In many cases the x-rays aid in making the diagnosis.

Treatment.—In treating bone-abscess, trephine the bone at the point of greatest tenderness, and if the abscess is missed, follow the advice of Holmes and perforate the wall of bone with the trephine, opening in several directions to discover the tuberculous matter or pus. It is often easy to open into the abscess with a chisel or gouge. After opening the cavity scrape its walls, remove dead bone, thoroughly dry with gauze, touch with pure carbolic acid, and pack with iodoform gauze. If the abscess opens into a joint, trephine the bone and open, irrigate, and drain the joint.

Caries was a term once used universally to signify suppuration or molecular death of bone. In some cases caries means suppurative osteitis; in others, tuberculous osteitis; in still others, gummatous osteitis. Typhoid fever is occasionally followed by a carious condition of bone. Osteitis is apt to become purulent when the bone is exposed to the air, when rest is not secured, when the health of the individual is below normal, when a foreign body such as a bullet is in the bone, or when tubercle or syphilis exists. The term is seldom used to-day except loosely, and then usually to signify tuberculous disease of bone. When caries arises, the softened and granulating bone breaks down and is discharged through a sinus. After drainage is secured organization, sclerosis, and healing may result. In these cases new bone may form and a cure follow.

Tuberculous or *strumous caries* (caseous osteitis), a condition produced by the caseation of the products of a tuberculous osteitis, shows no tendency to self-cure, no organization or sclerosis take place, and no new bone forms unless an operation is performed. The interior of bones, especially of the carpus and tarsus, is entirely softened and destroyed and thin shells only are left.

Caries necrotica is a condition in which small but visible portions of soft and dead bone are cast off; *caries sicca* is molecular death of bone without liquefaction or suppuration.

The caseating masses in tuberculous caries contain the tubercle bacillus.

If a tuberculous collection is evacuated and infection with pus organisms occurs, genuine suppuration takes place, and constitutional infection causes septic fever, and may cause death. Purulent osteitis may affect any part of any bone; but caseous osteitis (tuberculous caries) tends to arise especially in cancellous structures (heads of long bones, vertebral bodies, ribs and sternum, and bones of the carpus and tarsus). Tuberculous osteitis of the shaft of a long bone occasionally, but rarely, arises. Tuberculous osteitis is apt to cause tuberculous disease in an adjacent joint. Tuberculous osteitis may be followed by the formation of a cold abscess.

Symptoms.—In the beginning the evidences of caries are usually those of osteitis, but the first sign noted may be a fluctuating swelling due to pus or to caseated tubercle. After a time, at any rate, a fluctuating swelling is discovered. If not opened, the softened mass breaks externally, voids its contents, and leaves a sinus from which flows caseated matter which after a time becomes thin, reddish, and irritating to the skin, contains small portions of gritty bone, and has a foul smell. The opening of the sinus fills up with edematous granulations. A probe carried to the bottom of the sinus finds bone which is sieve-like (worm-eaten), and which on being struck gives a muffled note rather than the clear, sharp note of necrosis; the bone is rough, is bared, and is so soft that the probe can usually be stuck into it. In old cases of caries amyloid disease may arise.

Treatment.—If syphilis exists, give iodid of potassium in advancing doses and a mild mercurial course. If tuberculosis exists, give iodid of iron, arsenic, cod-liver oil, and nourishing foods, and recommend ocean air and living in the open air. Locally, in all cases, insist on rest and at once secure drainage, enlarging the opening, if necessary, and inserting a tube, and even making additional openings; syringe often with antiseptic fluids and dress antiseptically. If the case is seen before spontaneous evacuation has occurred, open under strict antiseptic precautions. When a chronic sinus exists there arises the question of operation. Incomplete operations are worse than useless, for they may be followed by diffuse tuberculosis or pyemia. If the gouge is used, try to remove *all* carious bone. The diseased bone is white, crumbles, and does not bleed; the non-carious bone is pink and vascular. Scrape away all granulations, swab the cavity with pure carbolic acid, and pack it with iodoform gauze. Instead of gouging away bone, there may be used the actual cautery, sulphuric acid, or hydrochloric acid. In severe cases excision is required, and in some rare cases amputation may be necessary. Caries of the spine is considered under Diseases of the Spine.

Necrosis is the death of visible portions of bone from circulatory impediment or the direct action of bacterial toxins. It is analogous to gangrene. One cause of necrosis is traumatism (such as the tearing off of periosteum) which deprives the bone of blood. Inflammation of the periosteum further lessens the nutrition. Acute inflammation in bone causes necrosis, the excessive exudation in the canals and spaces occluding the blood-vessels by pressure. The occlusion of vessels by septic thrombi may lead to necrosis, or the direct action of toxins may first inflame and finally destroy a portion of the bone. A thin shell of bone only may necrose from periosteal separation, or an entire shaft may die from acute pyogenic osteomyelitis or diffuse infective periostitis. Osteomyelitis

is the most usual cause of necrosis. Necrosis is most frequently met with in the diaphyses of the long bones, caries in the cancellous tissue of bones. The ribs may become carious, but very rarely become necrotic. A sequestrum may form in a vertebral body, in the carpus, or in the tarsus, but rarely does; hence, we conclude that sequestra do not often result from tuberculous osteitis. A fragment of dead bone is a foreign body; the healthy bone adjacent to it inflames and softens; granulations form, and this line of granulation, like the line of demarcation of gangrene, separates the dead part from the living, the white dead bone being surrounded by the red zone of granulation tissue. A bit of dead bone is called a "*sequestrum*," and Nature tries to cast it off. A superficial sequestrum is known as an "*exfoliation*."

Nature's method of casting off a sequestrum is as follows: suppuration takes place at the line of demarcation, osteitis extends for a considerable distance around this line, the periosteum shares in the inflammation, and new bone forms. A cavity is thus made within by suppuration, and a box or case forms without by ossification, the now entirely loosened sequestrum being so encased that it cannot escape. The pus finds its way through the new bone, and there is presented the condition so often seen by the surgeon—namely, a case of new bone known as the "*involucrum*," a *cavity* containing pus and the dead fragment or *sequestrum*, and a discharging sinus or "*cloaca*" (Fig. 194). Nature may eventually cast off the fragment, but the surgeon should not wait for the completion of this slow process.

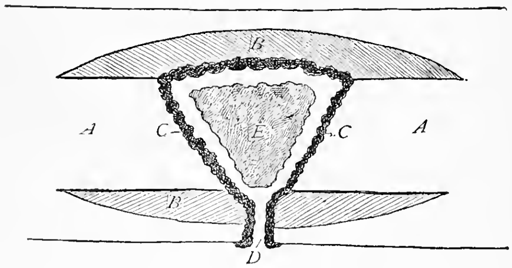


Fig. 194.—Diagram illustrating the formation of a sequestrum: *A*, Sound bone; *B*, new bone; *C*, granulations lining involucrum; *D*, cloaca; *E*, sequestrum.

When a portion of the bone surrounding the medullary canal dies, the condition is called "*central necrosis*." In some rare cases necrosis occurs without apparent suppuration, a painless swelling of bone simulating sarcoma. This condition is known as *quiet necrosis*, and has been described by Sir James Paget and Mr. Morrant Baker. Mercury is an occasional cause of necrosis. The fumes of phosphorus may cause necrosis of the lower jaw in those with decayed teeth. Necrosis may be produced also by frost-bites and burns. Many fevers (measles, typhoid, scarlet fever, etc.) are occasionally followed by necrosis. Syphilis and tuberculosis are occasional causes.

Symptoms.—The symptoms of necrosis are at first those of osteitis or osteomyelitis. The abscess, when formed, opens of itself or is opened by the surgeon, and a sinus or sinuses form in the soft parts as happens in caries. A probe introduced into the sinus strikes upon hard bone with a clear, ringing note, and often finds a sinus or sinuses in the bone. In superficial necrosis the discharge is slight and the probe shows the limitations of the disease. In extensive necrosis the discharge is profuse, much new bone forms, several sinuses appear far apart, and the probe must pass through a considerable thickness of new bone before it finds the bit of dead bone. The surgeon

should not operate until the dead bone is separated from the living by a line of demarcation, and until the sequestrum is loose. In youth dead bone loosens quickly, but in old age slowly. An exfoliation becomes loose sooner than the sequestrum of central necrosis. In diffuse periostitis the necrosed shaft loosens quickly. Necrosed portions of the upper extremity loosen more rapidly than those of the lower. In a young adult two or three months will be required to loosen a necrosed fragment in the lower extremity and from six weeks to two months in the upper. A loose sequestrum may be moved by the probe, and when struck gives a hollow note. In protracted cases of necrosis there is always danger that amyloid disease may arise.

Quiet necrosis is a rare condition which has led to some deplorable but pardonable mistakes, because it resembles ossifying sarcoma. It follows injury, particularly fracture. The bone enlarges greatly. There is little or no pain and no fever. The diagnosis can only be made by exploratory incision, and it may even be necessary to remove portions for microscopic study before a conclusion can be reached.

Postfebrile necrosis is most usually met with after typhoid fever. The bacilli of typhoid cause chronic osteomyelitis, and this is followed by necrosis. Scarlet fever, measles, and other febrile processes may also induce necrosis. It is certain that bacilli accumulate in the bones during typhoid fever. They may promptly induce disease; they may remain for long periods apparently inactive and finally pass away; or after a slight strain or injury these organisms may induce bone disease months or even years after the primary infection. *Typhoid bone disease* is often multiple, many bones being involved successively.* Not unusually after typhoid fever muscle strain causes periostitis and osteitis, and at such a point necrosis may occur. Either exfoliation or central necrosis may follow typhoid fever. The tibia is involved more often than other bone.

Treatment.—An exfoliation should be removed as soon as it becomes loose, the seat of trouble should be touched with pure carbolic acid, and packing of iodoform gauze should be inserted. The treatment of central necrosis comprises free incisions for drainage, antiseptic dressing, frequent cleansing, rest, nourishing food, stimulants, and tonics. When the sequestrum becomes loose the operation of *sequestrectomy* or *necrotomy* is performed, the extremity is drained of blood, an Esmarch band is applied, the bone is exposed by a longitudinal incision, the periosteum is reflected on each side, and the involucrum is broken through with the chisel, gouge, and rongeur. The dead bone should be removed by sequestrum forceps, the cavity scraped by a sharp spoon, the lateral edges of involucrum cut down until the cavity which formerly contained the sequestrum is very shallow, the wound is irrigated with hot salt solution, dried, painted with pure carbolic acid and then with alcohol, and firmly packed with iodoform gauze. Remove the Esmarch band, tie the vessels in the soft parts, suture the wound, and apply dressings. The simple removal of a sequestrum—*i. e.*, the operation of sequestrectomy—often fails to effect a cure, and even in the most satisfactory cases healing requires a very long time. "The involucrum always contains pyogenic germs that may live in its small foramina and crevices almost indefinitely. For this reason, and on account of the denseness of bony structure, it is well-nigh impossible to disinfect it"

* Keen's "Surgical Complications of Typhoid Fever."

(Dr. J. Shelton Horsley, in the "Medical Record," Oct. 20, 1900). Because of the difficulty of curing a case when involucrum has formed, Dr. Cushing, of Baltimore, has warmly advocated early operation in osteomyelitis; that is, operation before an involucrum has formed, and when the osteoblasts of the periosteum are extremely active. He points out that if an involucrum has formed, the sequestrum and involucrum should be removed after stripping the periosteum from this region. If the periosteum is found not to be infected, it may be stitched together at the gap where the bone has been removed, so that a periosteal cord exists between the two ends of the bone; and the soft parts above this may be closed. If the periosteum is found to be infected, we agree with Cushing that the cavity should be packed with gauze. The cavity that is left by the removal of a sequestrum and the chiseling of the walls of the involucrum, if large, may be filled by various methods more or less satisfactory. In some cases of widespread necrosis due to diffuse infective osteoperiostitis or to osteomyelitis extensive resection, or even amputation, may be necessary.

Treatment of Bone Cavities.—Schede does not pack the bone-cavity but allows it to fill up with blood-clot after the wound in the soft parts has been closed with sutures. The blood-clot obliterates the dead space in the bone, acts as a support for granulations from the margin, and is slowly eaten up. Unfortunately it is an excellent culture-medium and it often fails of its purpose. The surgeon may try to fill the cavity by taking flaps of skin from the sides of the wound, separating them freely from the fascia beneath and holding them within the bone cavity by inversion sutures or fastening them to the bottom with nails (*Neuber's operation*). Another operation consists in breaking the edges of the involucrum and turning them in. Some surgeons insert decalcified bone-chips. Bone-chips are prepared as described on page 72, and they are applied as is directed below. The cavity in the bone is made sterile and is well dusted with iodoform, the bone-chips are dried and inserted into the cavity, a capillary drain is employed, the periosteum is stitched over the opening, and the soft parts are sutured; but if this cannot be done, iodoform packing is used to keep the chips in place. This method we owe to the genius of Senn. Senn's method often fails because of the impossibility of completely sterilizing the walls of the bone-cavity. Attempts have been made to fill bone-cavities as a dentist fills teeth—with gutta-percha, plaster-of-Paris, copper amalgam, etc., but each of these materials acts as a foreign body in the bone (James E. Moore, on "the Treatment of Bone-cavities," "Jour. Am. Med. Assoc.," May 20, 1905). Schleich uses formalin-gelatin to fill bone-cavities. The difficulty in every case is the impossibility of completely sterilizing the walls of the cavity. Dressman has advised for this purpose the use of boiling oil, but it is apt to cause superficial necrosis. In some cases the cavity has been healed by the insertion of a Thiersch skin-graft. This method has been advocated by J. P. Lord ("Jour. Am. Med. Assoc.," May 31, 1902). Von Mosetig's method is one of the best. He pours into the cavity a melted material which completely fills the cavity, which will not act as a culture-medium or as a foreign body, which is gradually absorbed, and which "possesses the inhibitory and medicinal properties of iodoform without causing iodoform intoxication" (James E. Moore, on "The Treatment of Bone-cavities," "Jour. Am. Med. Assoc.," May 20,

1905). Mosetig's material consists of 60 parts of iodoform, 40 parts of spermaceti, and 40 parts of oil of sesame. These materials are mixed by heating gradually up to 100° C. On cooling a solid mass is formed. When the surgeon wishes to use it he heats it up to 50° C. and stirs it while heating (Moore), and pours it into the cavity in the bone. On entering the cavity it at once solidifies. A capillary drain is introduced, the periosteum is sutured with catgut, and the skin is sutured with silkworm-gut. Many attempts have been made to fill the defect by *bone-grafting*. The first case of satisfactory transplantation from one of the lower animals with the retention of a vascular attachment was reported by A. W. Morton in "American Medicine," July 12, 1902. The patient suffered from a compound comminuted fracture of both bones of the right leg. The fracture in the fibula united, but the tibia underwent necrosis, and it was necessary to remove five inches of the lower end of the bone. Some days later, the periosteum was raised from the ends of the bone and these ends were freshened. The left leg of a dog was amputated just above the tarsus, the bones being sawed so that the ulna was one inch longer than the radius. The lower end was partly bared of periosteum, and the ulna of the dog was forced into the cavity of the tibia of the man, and wired to that bone with silver wire. The incision in the man's leg was then sutured, and powerful tendons in each leg of the dog were divided. Each of the dog's other legs was wrapped separately in a plaster-of-Paris bandage, and the entire animal and the leg of the man were then put up in a plaster-of-Paris dressing. Five weeks later the cast was removed, and the bones were sawed and placed in contact with the astragalus. Union took place, and the man was fortunate enough to obtain a useful leg. In some cases a bone defect may be supplied by transference of another bone. Nichols reported 11 cases and insisted on the necessity of preserving the periosteum ("Jour. Am. Med. Assoc.," Feb. 3, 1904). Huntington has reported a case similar to 2 in Nichols's list. The patient was a boy of seven. A large piece of the entire thickness of the tibia was lost as a result of acute osteomyelitis. There was a gap of 5 inches between the ends of the bone, and the leg was a mere flail. Eight months after the beginning of the osteomyelitis the fibula was sawed opposite the lower end of the upper fragment of the tibia and the upper end of the lower fragment of the fibula was fixed in a cup-shaped depression in the lower end of the upper fragment of the tibia. Six months later union was solid, but in order to improve the weight-bearing power of the limb, nine months after the first operation, the lower end of the upper fragment of fibula was fastened to the upper end of the lower fragment of tibia. The result was excellent. The shortening is only three-fourths of an inch ("Annals of Surgery," Feb., 1905).

Acute osteomyelitis is an acute and diffuse inflammation of the bone-marrow due to pyogenic organisms. Infection from staphylococci may be limited to a portion of one bone. Streptococcus infection causes widespread involvement of a bone or of several bones. Acute osteomyelitis may be due to mixed infection with bacilli of typhoid and pyogenic organisms, or bacilli of tubercle and pyogenic organisms, a typhoid process or a tuberculous process serving to establish a point of least resistance. The gonococcus and the pneumococcus occasionally produce acute osteomyelitis. In a case of gonor-

rheal arthritis in which I resected the wrist-joint cultures of gonococci were obtained from the interior of the bone removed.

It was at one time believed that osteomyelitis was due to a specific organism, but Pasteur proved that micrococci are the cause, and Ogston demonstrated pyogenic bacteria in pus obtained from cases of osteomyelitis. In some cases there is pure staphylococcus infection (aureus or albus), both aureus and albus may be present, there may be mixed infection with streptococci and staphylococci, streptococci and several sorts of bacilli, or staphylococci and bacilli. Mixed infections with streptococci are more malignant than staphylococcus infections. Most cases of osteomyelitis are due to staphylococci. Ullman was unable to experimentally induce osteomyelitis without first creating by bone injury a period of least resistance. When he applied a ligature to a rabbit's leg for fourteen hours distinct changes were found to occur in the marrow of the bones. These changes consisted chiefly in extravasation and localized hemorrhages. When the marrow was in this condition, if virus were injected into the animal, osteomyelitis resulted, because the bones presented points of least resistance, vulnerable points in which pus cocci lodged and multiplied.

The pyogenic organisms may gain entrance directly by way of a wound (a gunshot-wound, a compound fracture, an amputation). The causative organisms may reach the bone by way of the blood, having entered the blood originally through the lymphatic system or from a focus of suppuration in the skin, the subcutaneous tissue, or a deeper part.

Pus organisms may pass into the blood from the tonsils or respiratory organs (Kraske); the intestinal canal (Kocher); the genito-urinary tract; or from excoriations, bruises, or small wounds in the skin (Warren). Certain fevers strongly predispose to the disease by preparing the soil as it were for the growth of pyogenic bacteria. Typhus fever, smallpox, malarial fever, scarlet fever, measles, and diphtheria lessen the vital resistance of bone-marrow. Typhoid fever is not unusually followed by a chronic osteomyelitis, due solely to typhoid bacilli. If mixed infection with pus organisms occurs, acute osteomyelitis arises. Vital resistance of marrow is lessened by exhausting diseases, overexertion, unhealthy and especially putrid food. We know that various infections produce various reactions in marrow, and in this changed marrow vital resistance is probably lessened or even seriously impaired. Longcope made a study of the marrow in 26 fatal cases of enteric fever, and he invariably found numerous lymphoid cells, phagocytes of large size, and multiple foci of distinct necrosis. The cells whose function is to form blood were noted to be undergoing hyperplasia. In those dead of perforation and general peritonitis there were numerous foci of necrosis, and also widespread degenerative changes in the blood-making cells and pronounced edema and congestion of the marrow ("A Text-Book of Pathology," by Alfred Stengel). When organisms gain entrance directly by a wound (as in a compound fracture), the endosteum, the medulla, and the cancellous tissue inflame and suppurate, and the entire length and thickness of the bone may be involved. The periosteum becomes infiltrated, detached from the bone, and retracted from the edges of the wound in the bone. The soft tissues around the bone may inflame, suppurate, or slough. More or less necrosis inevitably occurs.

Acute osteomyelitis without a wound is often called *acute epiphysitis* or *acute infantile arthritis*. This condition is most common in infants or children of one or two years of age, but occasionally arises in older children (from ten to fourteen years) or even in adults. It is most common during the period of active growth of bone. It is frequently preceded by one of the predisposing causes before mentioned. In many cases a strain or bruise is followed by pyogenic infection, because the damaged tissue extends a hospitable welcome to micro-organisms which are traveling in the body-fluids and pass through the injured area. In some cases chilling of the surface of the body is a predisposing cause. In others no predisposing cause is discoverable.

The compact bone suffers secondarily, but is never attacked primarily. New tissue is more susceptible to infection than old tissue, and the disease, as a rule, begins near the epiphyseal line, where new bone is being formed. This point was spoken of by Ollier as "the zone of election of pathological processes." Warren points out that in a growing bone near the epiphyseal cartilage there exists a newly formed spongy tissue, very vascular and connected with the cartilage by a spongy layer of tissue, which is not yet bone, but which does not possess a cartilaginous structure. It is in this portion of the skeleton that the most active changes take place during the period of growth. The medullary substance is very vascular at this point; it is red and without fatty tissue. It communicates with the medullary canal and with the periosteum by a number of vascular channels. The epiphyseal cartilage itself is intimately blended with the periosteum. The diaphyseal side of the cartilage produces much more bone than is found in the epiphyseal margin. There is also an active growth of bone in the periosteum, and it is in these regions and in the medullary canal that the inflammatory process originates.* The lower end of the femur and the upper end of the tibia are the regions most commonly attacked; but the upper end of the femur and the lower end of the tibia may suffer, and other bones may be attacked, especially the humerus, radius, ulna, and inferior maxilla. The adjacent joint not unusually becomes involved. Though the inflammation begins in the spongy tissue or medulla, it passes to the canals and spaces of the compact bone. The inflammatory exudate in the canals compresses the vessels and cuts off nutrition from certain areas. Suppuration begins, clots form in the medulla from thrombophlebitis, and the clots in the vessels of the Haversian canals become septic. A small sequestrum forms at the seat of origin of the disease, and the pus about the sequestrum is apt to empty into the medullary canal, causing diffuse osteomyelitis, or into the adjacent joint, causing suppurative inflammation of the articulation.

Marked constitutional symptoms arise from absorption of toxins (suppurative fever), and sometimes true septic infection or even pyemia arises.

Very extensive necrosis may follow osteomyelitis if the patient recovers.

Symptoms.—Osteomyelitis secondary to a wound may occur in a person of any age. If a wound exists,—for instance, a compound fracture,—the diagnosis is evident. The constitutional symptoms of septic absorption are positive: there is a profuse, offensive, purulent discharge containing bone-fragments and tissue-sloughs; the periosteum is red, thick, and separated; there are swelling over the bone, great tenderness, and violent boring, gnawing,

* Warren's "Surgical Pathology."

or. aching pain. Osteomyelitis occurring without a wound, the condition known as acute epiphysitis, occurs in the young, and particularly in children under three years of age.

The symptoms of acute epiphysitis usually come on suddenly and especially at night, and the attack may be so acute as to cause death by systemic poisoning before a diagnosis is arrived at. The disease is generally ushered in by a chill, which is followed by septic febrile temperature. The history will sometimes contain the statement that a blow had been received, that a febrile process had existed, or that the patient had been suddenly chilled after having been overheated (sitting in a draft or in a cellar on a hot day, possibly swimming when very warm, etc.). There is violent aching pain in the bone and acute tenderness near the joint; the soft parts, which at first are healthy in appearance, after a time discolor, swell, and present distended veins, and may become glossy and edematous because pus is gathered below. An abscess sometimes reaches the surface and may break spontaneously. The neighboring joint swells, and may become filled with pus; the periosteum and the shaft are involved for a considerable distance; each epiphysis may become affected, the shaft between being comparatively uninvolved, and the epiphyses may separate, displacement and shortening taking place. This disease is often mistaken for rheumatism because of the joint-swelling, occasionally for typhoid fever because of the fever, and in some cases for erysipelas because of the redness of the skin. It gives a very grave prognosis. Sometimes an epiphysitis shows milder symptoms and is slower in progress (subacute). These cases are very often mistaken for rheumatism. But in rheumatism the joint is the part involved from the beginning, while in epiphysitis the joint is involved secondarily after obvious evidence of inflammation well clear of the articulation. Further, the symptoms of rheumatism will be rapidly improved by the use of the alkalies or the salicylates.

Treatment.—If a wound exists, apply a tourniquet, sterilize the parts, enlarge the wound, expose and curet the medullary cavity, remove loose fragments of bone, irrigate the medullary cavity with a hot solution of corrosive sublimate or hot salt solution, scrape it with bits of gauze held in the bite of a forceps, paint with pure carbolic acid, pack lightly with iodoform gauze, dress with hot antiseptic fomentations, and secure rest for the parts by splints and bandages. The constitutional treatment is the same as that for septicemia. Acute osteomyelitis without a wound is a most serious condition, rapidly progressive, apt to be quickly fatal, and requiring prompt and radical treatment. In treating it do not wait for fluctuation, but incise at once; break through the bone at one or more points with a gouge or chisel; chisel away the diseased bone, and if necessary curet the medullary canal; irrigate with hot corrosive sublimate solutions or hot salt solution; swab with pure carbolic acid; use iodoform plentifully; pack with iodoform gauze; dress with hot antiseptic fomentations; drain the joint if it is involved; employ rest, anodynes, strong supporting treatment, and other remedies advised in septicemia. Remove dead bone subsequently when it becomes loose. Amputation may be required in either form of the disease.

Chronic osteomyelitis is usually linked with osteitis. It may eventuate in osteosclerosis with filling up of the medullary canal, in limited suppuration, in caseation of the cancellous tissue (Brodie's abscess), or in

necrosis. A tuberculous inflammation is one form of chronic osteomyelitis. Syphilis, typhoid fever, etc., may cause it, and it can be caused by glanders, leprosy, and actinomycosis.

The typhoid bacillus under certain conditions is pyogenic. Fränkel taught this some years ago, and Keen seems to prove it in his work on the Surgery of Typhoid Fever. Osteomyelitis due purely to typhoid bacilli is chronic. When the medulla contains typhoid bacilli pus infection is apt to take place, and if such a mixed infection arises acute osteomyelitis develops.

In chronic osteomyelitis there are pain, tenderness, and swelling, but no marked constitutional symptoms. In some cases the real trouble is not identified until an abscess forms (see Necrosis).

Treatment.—If an abscess exists, at once evacuate it by incising the soft parts and chiseling the bone. Do not wait for an involucrum to form, but promptly incise, disinfect and drain. If dead bone is present it must be removed.

Osteomalacia, or Mollities Ossium.—In this disease the bones are partly decalcified, and consequently soften and bend. Masses of new uncalcified bone-tissue are formed. Many bones are usually involved, but bones of the head are not obviously affected. It is commoner beyond than before middle age, though it may occur in infancy; it is more frequently met with in women than in men, and pregnancy seems to bear more than a casual relation to its production. In osteomalacia the medulla increases in bulk and becomes more fatty, and the osseous matter is absorbed gradually, first from the cancellous tissue and then from the compact tissue. Some observers believe that this curious condition is due to lactic acid in the blood, an abnormal amount of acid having been produced and absorbed because of disorder of the primary assimilation. Volkmann asserts that some inflammatory condition disturbs the blood-supply of the medulla, and von Recklinghausen asserts that arterial hyperemia is responsible.

Symptoms.—The symptoms of osteomalacia are as follows: many points of pain which are often thought to be due to rheumatism; deformities from twisting and bending of bone; and a large excess of calcium salt in the urine. Fractures occur from very slight force. In the majority of cases the disease is not cured, but grows progressively worse until the patient dies, after many years, from exhaustion. In some cases the process is arrested and the osteoid tissue is calcified.

Treatment.—In treating osteomalacia in women insist that pregnancy must not occur. Put braces and supports upon distorted limbs to prevent further bending and fracture. Advise hygienic surroundings and nourishing food, and insist on the value of fresh air. Among the medicines that can be used may be mentioned cod-liver oil, lime salts, preparations of phosphorus, and bone-marrow. In women the removal of the ovaries sometimes produces cure. It has been asserted that the production of anesthesia by means of chloroform may be of benefit.

Acromegaly.—This is a disease which causes progressive and often great enlargement of both the bones and soft parts of the extremities, which enlargement is symmetrical. The cranium becomes triangular in shape, with the base below at the lower jaw. The lower jaw projects in advance of the upper jaw, the nose becomes prominent and thick, the supra-orbital ridges

are accentuated, and the costal cartilages and inner ends of the clavicles become protuberant. Later the larynx, ribs, shoulder-blades, and vertebræ become involved, and the back becomes markedly humped (cervicodorsal hump). The hands and feet are affected in advanced cases. As a rule, the thyroid gland is enlarged, and a post-mortem examination may detect an enlarged pituitary gland. Severe and uncontrollable headache is sometimes a distressing feature of the disease. Treatment is futile. The disease slowly but surely causes death.

Leontiasis Ossium (Virchow's Disease).—This is a symmetrical hypertrophy limited to the facial and cranial bones, and which begins, as a rule, in the superior maxillæ. The hypertrophy progressively increases, causes difficulty of mastication, and is accompanied by headache. It produces distinct deformity of the jaw like a tumor, whereas acromegaly enlarges all of the proportions of a bone (Fig. 195). It may produce blindness, new bone pressing upon the optic nerves. Treatment is not satisfactory, as a rule. Recently Horsley has obtained amelioration by operating and removing masses of bone.

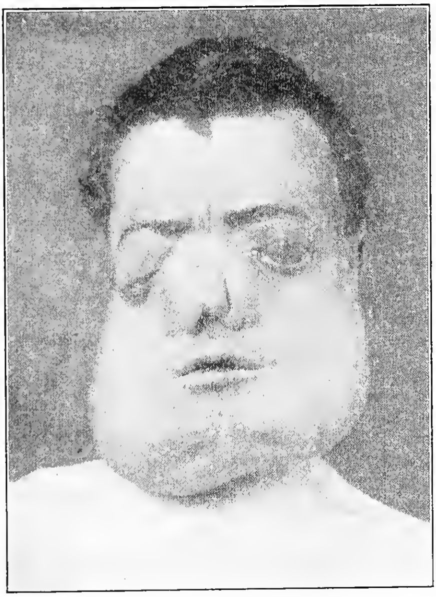


Fig. 195.—Leontiasis ossium.

Ostitis Deformans (Paget's Disease).—This disease was first described by Paget in 1877, and in the neighborhood of 100 cases have been reported. Packard and Steele ("Amer. Jour. of Med. Sciences," Nov., 1901) point out that many of the reported cases are not genuine instances of the disease, some being ordinary osseous tumors, others being cases of enlargement after fracture, and still others being instances of mollities ossium. They think that 67 of the reported cases are genuine instances of the disease. In this disease great quantities of new bone are formed, but calcification does not occur. The material undergoes absorption, and the medullary substance of the bone becomes extremely vascular and filled with white blood-cells, and also with giant-cells. The fact that the new bone does not calcify leads to various deformities of the long bones, on account of the weight of the body; but fracture is not particularly apt to occur. Numbers of bones may be decidedly thickened. The underlying cause of this curious condition is entirely unknown, but it is assumed to be trophic. It is claimed that it has occasionally arisen after an injury to a long bone, and has been excited into activity by heat and cold. It is extremely rare before the age of forty, and usually begins between forty and fifty. The enlargement of the bones may be first detected in the cranium, but is more often first seen in some other bone

—for instance, the clavicle, the tibia, the spine, or the radius. In fact, in some cases the bones of the head do not enlarge at all; but, taking all the reported cases, the skull is affected more frequently than any of the other bones. In some cases, the enlargement of the bones seems to be symmetrical; in others, it is not. In the disease known as leontiasis ossium, the chief enlargement is manifested in the face; in Paget's disease there is no enlargement of the bones of the face, or else these bones are trivially involved. Packard and Steele point out that the diagnosis is extremely difficult when but a single bone is involved; but that if two or more bones are involved, we should think of Paget's disease as the condition, especially if we are able to exclude syphilis, cancer, and sarcoma. In mollities ossium the head is not involved at all; and there is not nearly so much thickening of the bone. The two authors before quoted show that in acromegaly the cranium is a triangle with its base below at the lower jaw, the orbital arches being chiefly involved; but that in Paget's disease the involvement is chiefly of the calvarium. In this curious malady there may or may not be pain. The patient actually diminishes in height. The chest becomes deformed. There is angular curvature in the dorsocervical region. The lower extremities are usually bent; and the pelvis, as a general thing, is broadened. In the 67 cases collected by Packard and Steele, 3 suffered with cancer and 5 with sarcoma.

Treatment.—Treatment is practically useless. No known remedy diminishes the size of the bones, although iodid of potassium is said occasionally to mitigate the pain, if pain exists.

Fractures.

Definition.—A fracture is a solution, by sudden force, of the continuity of a bone or of a cartilage. Clinically, under this head are placed epiphyseal separations and the tearing apart of ribs and their cartilages.

Varieties of Fractures.—The varieties of fractures are as follows:

Simple fracture is a subcutaneous fracture, or one in which there is no

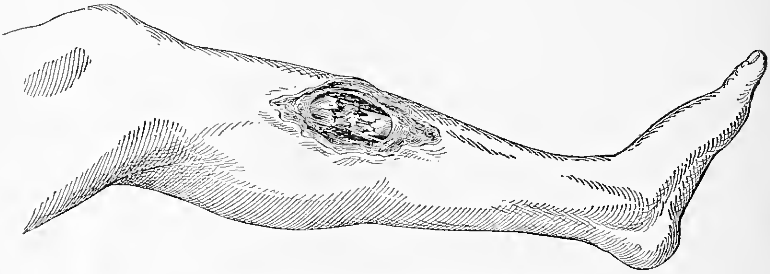


Fig. 196.—Compound comminuted fracture of the tibia.

wound extending from the surface to the seat of bone-injury. This corresponds to a contusion of the soft parts.

Compound fracture (Fig. 196) is an open fracture, or one in which an open wound extends from the surface to the seat of bone-injury or in which a wound opens up a passage from the fracture to the surface. This corresponds to a contused or lacerated wound of the soft parts. The opening may be through

the skin; through a mucous membrane, as in some fractures of the base of the skull and pelvis; through the drum of the ear, as in some fractures of the middle fossa of the base of the skull; through the lung, as when a broken rib penetrates that organ; or through the bowel or bladder, as in some fractures of the pelvis.

A primary compound fracture is one in which the breach in the soft parts

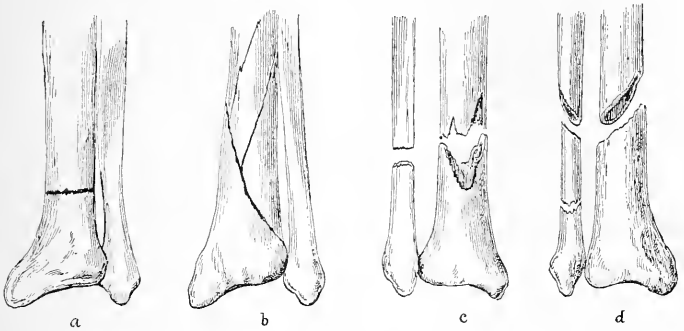


Fig. 197.—Complete fractures: *a*, Transverse; *b*, spiral; *c*, dentated; *d*, oblique or multiple.

is produced at the time of the accident, either by the direct violence of the injury or by the forcing of a bone or bones through the tissues.

A secondary compound fracture is one in which the breach in the soft parts occurs after the accident, either from sloughing of damaged tissues, from ulceration because of the pressure of ill-adjusted fragments, or from the forcing of a bone or bones through the soft parts because of rough handling, neglect, or the tossing of delirium.

Complicated fracture is a fracture plus the complication of a joint-injury, arterial or venous damage, or injury to the nerves or soft parts. When a fractured rib injures the lung or when a broken vertebra damages the cord a complicated fracture exists. The term is unfortunate, as it conveys no definite meaning, and its use is no more justifiable than it would be to speak of "complicated pneumonia" or "complicated typhoid," for the complication should be named in any case. It must be remembered that damage to the soft parts not sufficiently severe to produce a wound reaching from the surface to the seat of fracture does not make the case a compound fracture, but rather complicates a simple fracture. Remember also that even superficial areas of tissue-destruction must be treated antiseptically, otherwise absorption of pyogenic bacteria and their deposition at the seat of injury may cause diffuse osteomyelitis.

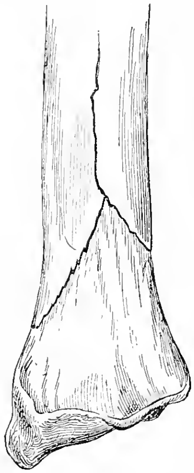


Fig. 198. — Longitudinal and oblique fracture.

Complete fracture is that which extends through the whole thickness of a bone or entirely across it (Fig. 197).

Incomplete fracture is that which extends only partially through the thickness of a bone or only partially across it.

A *linear, hair, capillary,* or *fissured fracture,* or *a fissure,* is a crack in a bone with very little separation of the edges. This is an incomplete fracture, but may be associated with a complete break.

Fig. 199.—Green-stick fracture.

A *green-stick, hickory-stick, willow,* or *bent fracture* is a true incomplete break (Fig. 199). The bones most frequently broken are the radius, ulna, clavicle, and ribs. It arises from indirect force, and it is very rare after the age of sixteen. In rickets green-stick fractures are very common. It is called "green-stick" because the bone breaks like a green stick when forced across the knee, first bending and then breaking on its convex surface. The bone, being compressed between two forces, bends, and the fibers on the outer side of the curve are pulled apart, while those on the concavity are not broken, but are compressed. In correcting the deformity such fractures are often made complete. The permanent bending of a bone without a break may possibly occur in youth. In children a portion of a bone of the skull may be bent inward, causing depression. In some cases such a depression is permanent; in others it is temporary, the bone returning to its proper level.

Depression-fracture occurs when a portion of the thickness of a bone is driven in by crushing. Fracture by depression is a result of the bending in of a bone (as the parietal), a fragment breaking off from the side toward which the bone is bending. A *depressed fracture* is complete, not incomplete, and by this term is meant an injury in which a fragment of the entire thickness of the bone is driven below the level of the surrounding surface.

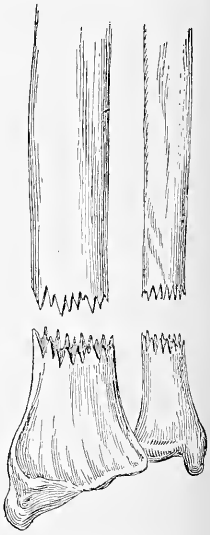


Fig. 200.—Appearances of the ends of fragments.

Splinter- and Strain-fracture. — The breaking off of a splinter of bone (splinter-fracture) or of an apophysis constitutes a form of incomplete fracture. A strain upon a ligament or a tendon may tear off a shell of bone, and this injury is the "strain-fracture" or "sprain-fracture" of Callender.

Longitudinal fracture is a fracture whose line is for a considerable distance parallel, or nearly so, with the long axis of the bone. Such fractures are common in gunshot-injuries (Fig. 198).

Oblique fracture is a fracture the direction of which is positively oblique to the long axis of the bone. Most fractures from indirect force are oblique (Fig. 197, *d*).

Transverse fracture is a fracture the direction of which is nearly transverse to the long axis of the bone (no fracture is mathematically transverse) (Fig. 197, *a*). The cause is often, but not invari-

ably, direct force. The "*fracture en rave*" (radish-fracture, so called because the bone breaks as does a radish) is transverse at the surface, but not within.

Toothed or *dentate fracture* is a form of fracture in which the end of each fragment is irregularly serrated and the fragments are commonly locked together; hence it is difficult to correct the deformity (Fig. 197, *c*, and Fig. 200). Most simple fractures from direct force are serrated.

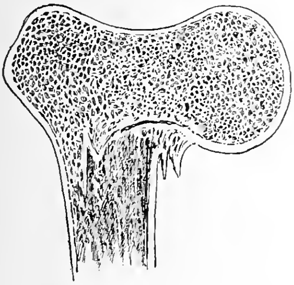


Fig. 201.—Impacted fracture of the neck of the femur.

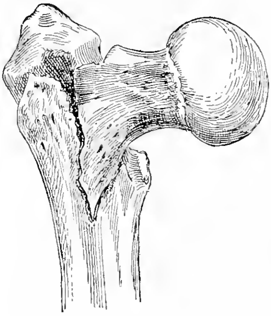


Fig. 202.—Impacted fracture of the neck of the femur.

Wedge-shaped, V-shaped, cuneated, or *cuneiform fracture* ("fracture oblique spiroïde," "fracture en V" of Gosselin, "fracture en coin") is one the lines of which take the shape of a V, which may be entire or may lack the point. It occurs at the articular extremity of a long bone, and a fissure usually arises from its point and enters the joint. If complete, it is a "comminuted fracture."

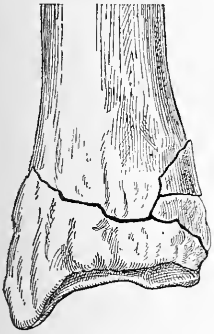


Fig. 203.—Comminuted fracture of the lower extremity of radius.

T-shaped fracture is a fracture which presents a transverse or oblique line and also a longitudinal or vertical line. It occurs at the lower end of either the humerus or femur, the transverse line being above, and the vertical line (intercondyloid) between, the condyles. If complete, it is in reality a form of comminuted fracture.

Multiple or *composite fracture* is a condition in which a bone is broken into more than two pieces, the lines of fracture not intercommunicating, or a condition in which two or more bones are broken. Multiple fractures of one bone are divided into double, treble, quadruple, etc.

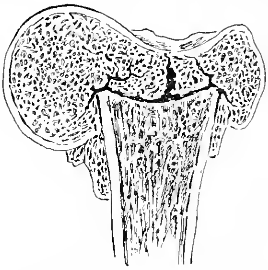


Fig. 204.—Comminuted fracture of the upper part of femur.

Comminuted fracture is a condition in which a bone is broken into more than two pieces, the lines of fracture intercommunicating (Figs. 203 and 204). The bone may be broken into many small fragments, there may be much splintering, or the osseous matter may actually be ground up.

Impacted fracture is one in which one fragment is driven into the other and solidly wedged (Figs. 201, 202, and 205).

Fracture with crushing or *penetration* is a fracture in which one bone is driven into the other, the encasing bone being so splintered that the impacting bone is not firmly held.

Pathological, spontaneous, or *secondary fracture* is one occurring from a very insignificant force acting on a bone rendered brittle by disease.

Ununited fracture is a fracture in which bony union is absent after the passage of the period normally necessary for its occurrence.

Direct fracture is one occurring at the point at which the force was primarily applied.

Indirect fracture is one occurring at a point distant from the area of primary application of force.

Stellate or *starred fracture* (fracture par irradiation) is one in which several fissures radiate from a center. If the fractures be complete, the condition is in reality a form of comminuted fracture.

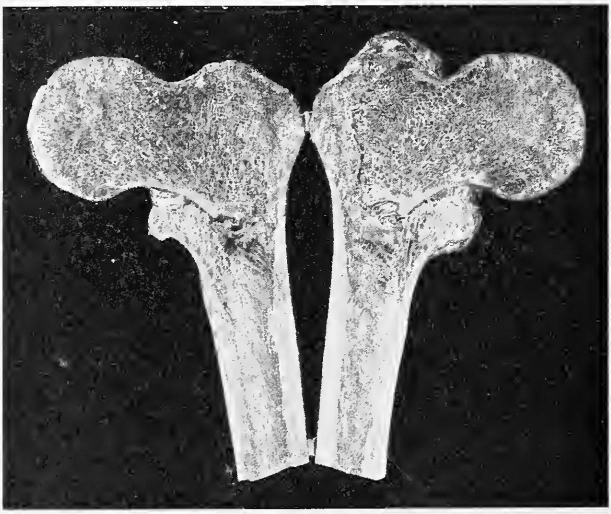


Fig. 205.—Impacted fracture of neck of femur (Conner).

Helicoidal, spiral, or *torsion fracture* is a fracture resulting in a long bone from twisting.

Fracture by contrecoup is a fracture of the skull which is on the opposite side of the head to that which was the recipient of the force.

Epiphyseal Separation or Diastasis.—This injury occurs only before the age of twenty-five. In order of frequency, the bones chiefly subject to epiphyseal separation are: the upper end of the humerus, the lower end of the radius, the lower end of the femur, and the lower end of the tibia (John Poland, in the "Practitioner," Sept., 1901). This injury induces deformity, which is often difficult to reduce, and by damaging the cartilage may retard or inhibit a further lengthening of the limb by growth. Occasionally, after damage to an epiphysis suppuration will occur, sometimes thickening takes place. Non-union is very rare. After a sprain of an epiphysis tuberculous disease sometimes develops, but very rarely after a separation.

Intra-uterine fractures are usually due to injuries of the mother's abdomen sustained toward the end of pregnancy. Some hold that they can arise as a consequence of the force of violent uterine contractions. Many so-called "intra-uterine" fractures are wrongly named, as they result from injury during delivery. In sporadic cretinism the bones are fragile and ill-ossified, and many fractures may occur *in utero*.

Designation According to Seat of Fracture.—A fracture may be designated according to its anatomical seat; for instance, fracture of the upper third of the shaft of the femur, fracture of the olecranon process of the ulna, fracture of the middle third of the clavicle, and fracture of the body of the lower jaw. *Intra-articular* fracture is one extending into a joint; *intracapsular* fracture is one within the capsule of either the shoulder- or hip-joint; and *extracapsular* fracture is one just without the capsule of either the shoulder- or hip-joint.

Causes of Fracture.—The causes of fracture are (1) exciting, immediate or direct, and (2) predisposing or indirect.

Exciting causes are (*a*) external violence and (*b*) muscular action.

External violence is the most usual exciting cause. Two forms are noted: (1) direct violence and (2) indirect force.

Fractures from direct violence occur at the point struck, as when the nasal bones are broken with the fist. In such fractures the soft parts are injured; they may be destroyed at once in part, they may be damaged so severely that a portion sloughs, or they may be damaged so slightly that they do not lose vitality; hence fractures by direct violence may be compound from the start, may become so, or may remain simple. In fractures by direct force discoloration, due to effused blood, usually appears at the point struck soon after the accident. In compound fractures by direct violence the soft-part injury is so great that primary tissue-union cannot occur.

Fractures from indirect force do not occur at the point of application of the force, but at a distance from it, the force being transmitted through a bone or a chain of bones, as when the clavicle is broken by a fall upon the extended hand. Such fractures tend to occur in regions of special predilection. If they are not compound, there is no injury of the surface over the fracture. If they become compound by projection of fragments, primary union may still occur. Discoloration over the seat of fracture is usually not present soon after the accident, but may occur later. Discoloration rapidly appears in soft parts at the point where the force was first applied.

Muscular action is rather an unusual cause. Fractures thus produced result from sudden or violent muscular contraction. Bones so broken are usually diseased. Violent coughing may fracture the ribs; attempting to kick may fracture the femur; saving one's self from falling backward may fracture the patella; throwing a stone may fracture the humerus; and sudden extension of the forearm may fracture the olecranon process of the ulna.

Predisposing Causes.—There are two classes of predisposing causes, namely: (1) physiological, natural or normal, and (2) pathological or abnormal.

Natural Predisposing Causes.—Under this head is considered the liability to fracture possessed by individual bones because of their shape, structure, function, or position. Those predispositions occasioned by special ages are

also considered. In youth epiphyseal separation is commoner than fracture and a fracture is apt to be incomplete. Fractures are commonest between the ages of twenty-five and sixty. From two to four years of age a child is more liable to fracture than later, because he is then learning to walk (Malgaigne). The bones of the old are easily broken, but the normal lack of activity of the aged saves them from more frequent injury. Thus the predispositions of age are in part due to habits and in part to bony structure. The bones of the young, being elastic, bend considerably before they break; the bones of the old, being brittle and inelastic, break easily, but do not bend. In old age the bones become lighter and more porous, though they do not diminish in size. Absorption takes place from the interior of a bone, particularly at its articular head, the medullary canal increases in size, the cancellous spaces become notably larger, and portions of the remaining bone of the interior show a fatty change. There is no increase in the amount of mineral salts present, as was long taught. These alterations occur earlier in women than in men.* The change of age is a diminution in the amount of bone present, and sometimes a fatty change in a portion of what remains. If the atrophy of bone is other than that normal to senility, it constitutes a pathological predisposing cause of fracture. Normal predisposing causes include the person's weight (which determines the force of a fall), muscular development, habits, sex, occupation, and the season of the year.

Pathological Predisposing Causes.—Hereditary fragility, a form of *fragilitas ossium*, is a condition commonest among women, often existing in generation after generation, and in this condition fractures occur from a very slight force. There exists in these cases bony rarefaction—in fact, a premature senility. Fragilitas ossium may result from senility, from wasting diseases, from certain nervous disorders, from rickets, from osteomalacia, and from atrophy due to disuse.

Nervous Diseases.—Bony nutrition is dependent on the spinal cord, and the trophic influence is probably exerted through the posterior nerve-roots (Gowers). In diseases of the anterior cornua bony growth is much interfered with; in diseases of the posterior columns, as in locomotor ataxia, a true bony atrophy bespeaks trophic disorder. Syringomyelia causes brittleness of the osseous structures, and in paralysis agitans bones are thought to break easily. Trophic changes may occur in the bones of the insane, most commonly when insanity is linked to organic disease. About one-quarter of paretic dements show undue brittleness or unnatural softness of bones.† The bones of maniacs are frequently fragile. Fractures among the insane are not necessarily an indication of abuse.

Rickets.—Rickets predisposes to fracture because of altered bone-structure and the great liability to falls.

Osteomalacia predisposes to fracture of the long bones, sternum and ribs.

Atrophy of Bone.—This condition, as has been stated (page 431), is normal in senility. It may arise from want of use, as is observed in the bedfast in the wasted femur of hip-joint disease, and in the bones of a stump. It may arise from pressure, as when an aneurysm compresses the ribs, sternum, or vertebræ. Among other of the pathological predisposing causes are to be

* Humphrey on "Old Age."

† "Manual of Insanity," by Spitzka.

mentioned cancer, sarcoma, hydatid and solitary cysts of bone, caries, necrosis, gout, scrofula, syphilis, mollities ossium, and scurvy.

Symptoms of Fracture.—*History of an Injury.*—In spontaneous fracture there may be no record of violence; for instance, a bone may break while an individual is turning in bed. In investigating the history, not only seek for a record or for evidences of violence, but try to determine exactly how the accident happened.

A sound of cracking is occasionally audible to a bystander at the time of the injury. The patient may have heard it, but very rarely does. A rupture of a tendon or a ligament produces a similar sound.

Pain is usually, but not invariably, present (absent often in rickets). Malgaigne says that in some fractures the pain is slight or absent, in others it is torturing, and in most it is severe for a time after the injury, but gradually abates unless reinduced by movement. Pain developed at the time of the accident is far less important as a symptom than that which can subsequently be produced by movement. In indirect fracture there is an area of pain at the point of application of the force, and another at the seat of fracture. Pain at the seat of fracture can be greatly aggravated by pressure or movement and is rather narrowly localized.

Deformity or *alteration in length or outline* is due in part to swelling and in part to a change in the mutual relation of the fragments (displacement). The deformity due to swelling is no aid to diagnosis, as the same condition occurs in contusion, and often hides some positive symptomatic distortion. The swelling is due first to blood and next to inflammatory products and pressure-edema, and is very great in joint-fractures. The deformity of displacement may be produced by the violence of the injury (as is the depression in a skull-fracture), by the weight of an extremity (as is the falling of the shoulder in a fracture of the clavicle), or by muscular action (as is the pulling upward of the superior fragment of a fractured olecranon process).

The **varieties of displacement** are (1) *transverse* or lateral, where one fragment goes to the side, front, or back, but does not overlap the other; (2) *angular*, the bony axis at the point of fracture being altered and the fragments forming with each other an angle; (3) *rotary*, one fragment rotating in the bony circumference, the other remaining stationary. As a rule, it is the lower fragment which turns on its long axis, the limb below the level of the break rotating with it; (4) *overlapping* or overriding, when the upper level of one fragment is above the lower level of the other fragment. It is usually the lower fragment which is drawn by the muscles above the upper, but in a fracture of the lower extremity the body-weight and sliding down in bed may push the upper below the lower fragment. In overriding the ends are near together and the bones are usually in contact at their periphery. It is obvious that overlapping is associated with transverse displacement, as one fragment must go front, back, or to the side; (5) *penetration* or impaction when one fragment is driven into the other, thus producing shortening; (6) *separation* of the two fragments occurs in fracture of the patella, olecranon, os calcis, certain articulations, and in some breaks of the humerus when the arm is not supported.

It is important to remember that a dislocation as well as a fracture may produce displacement, but these two conditions may be differentiated by

the observation that the displacement of fracture tends to reappear even after complete reduction, while the displacement of dislocation does not reappear after correction. A displacement is difficult of detection in a flat bone and when one of two parallel bones is broken.

Loss of function may be shown by inability to move the limb because of the break, but it is not always markedly present, though some degree invariably exists. It is slight in "green-stick" and impacted fractures (unless the loss of power arises from pain or nerve-injury). A person can walk when the fibula alone is broken, and likewise in some cases of intracapsular fracture of the femur, and can often put the hand on the head in fractured clavicle (Malgaigne). The pain of any injury or the loss of power from nerve-traumatism may cause loss of movement in the limb. This symptom is of slight diagnostic value in most fractures.

Extravasation of Blood.—A contusion of the surface accompanied by skin-abrasion indicates merely the point of application of direct external violence. If contusion is extensive over a superficial bone, as the tibia or parietal, after a few hours it often stimulates fracture by presenting a soft, compressible center surrounded by a ring of hard, condensed tissues and coagulated blood. Direct external violence may merely occasion ecchymosis, and in fracture from indirect force ecchymosis may occur throughout a considerable area. In regard to this symptom, note that even great external violence may occasion no evident contusion or ecchymosis, and in any fracture this symptom may be present or absent. In old people, anemic subjects, alcoholics and opium-eaters, extravasation of blood is frequently marked and persistent. By suggillation is meant an extravasation of blood which slowly invades wide areas of tissue and which appears at the surface only after some time, and then usually as a yellowish discoloration, red hemoglobin having been changed to yellow hematoidin. Linear ecchymosis has been esteemed by some as a sign of fissure, and it is often noted after fracture of the fibula. Linear ecchymosis over the line of the posterior auricular artery was shown by Battle to be a valuable sign of fracture of the posterior fossa of the base of the cranium.

Preternatural mobility is a most important symptom, which is pathognomonic when surely found. The unbroken bone is nowhere mobile in continuity. By preternatural mobility is meant that a bone is mobile in continuity or that there is abnormality in the direction or extent of joint-mobility. In some fractures this symptom does not exist (impacted, green-stick, and locked serrated fractures); in others it cannot be found (fractures of tarsus, carpus, vertebral bodies); in others it is difficult to obtain, but at times can be developed (fractures near or into many joints). To develop this symptom, try, when the case admits, to grasp the fragments and to move them in opposite directions. In a fracture of the shaft of the femur or humerus fix the upper fragment and carry the knee or elbow in various directions to develop bending at the point of fracture. In fracture of the clavicle push the shoulder downward and inward. In fractures of either bone of the forearm grasp the parallel bone with four fingers of each hand and make pressure on the suspected bone alternately with either thumb, and the same procedure can be used in fractures of the leg. In fracture of the neck of the femur the altered rotation-arc of the great trochanter demonstrates preternatural

mobility (Desault). In fracture of the lower end of the radius bend the hand back, and in a break of the lower end of the fibula evert the foot (Maisonneuve). In seeking preternatural mobility, remember that the elastic ribs when forced in give a sense of bending, and that the fibula at its middle is "normally flexible" (Dupuytren). Some rachitic bones may be bent.

Crepitus or *crepitation* is both a sensation and a sound, which indicates the grating together of the two rough surfaces of a broken bone. This symptom is of great value, but it is not always present. It is absent in locked serrated fractures, in impacted fractures, in cases where the broken ends cannot be approximated (as in overlapping), is rare when a fractured surface is against the side, and not the broken face, of the other fragment, and is unusual in incomplete fractures. Crepitus is often absent in epiphyseal separation, in softened bones, and in fractures in or near joints, and it may be prevented from occurring by blood-clot, fascia, synovial membrane, periosteum, or muscle between the broken surfaces. The grating found in tenosynovitis must not be mistaken for the crepitus of fracture: the former is diffuse, large, soft, and moist; the latter is limited, small, harsh, and dry. The clicking of an inflamed or eroded joint and the crackling of emphysema must also be separated from bony crepitus. Crepitus of fracture may be present at one moment, but absent the next. It is often not detected during the time swelling is marked, and cannot be discovered after organization of the callus begins. In but few fractures is it needful to try to hear crepitus with the unaided ear or with a stethoscope upon the part, but in doubtful cases of fractures of ribs and joints this evidence should be sought for.

The above-named symptoms are known as "direct." There are other symptoms known as "circumstantial," such as the flow of blood and cerebrospinal fluid from the ear after some fractures of the middle fossa of the skull; emphysema of the face and epistaxis after fracture of the nasal bones; hemoptysis and emphysema after crushes of the chest; discoloration following the line of the posterior auricular artery after fracture of the posterior fossa of the skull; and subconjunctival ecchymosis after fracture of the anterior fossa of the skull.

Diagnosis.—Examine as soon as practicable after the injury—before the onset of swelling, if possible. Expose the part completely, taking off the clothing, if necessary, by clipping it along the seams. Attentively scrutinize the part and compare it with the corresponding part on the opposite side. If any deformity be present, it must be ascertained that it did not exist before the accident. If the nature of the injury be uncertain, if the patient be very nervous, or if the part be acutely painful, it is better to give ether to diagnosticate, set, and dress. In injuries of the elbow-joint anesthetize before examination, unless an *x*-ray apparatus is accessible to settle the diagnosis, and even then it is usually well to anesthetize in order to facilitate reduction and dressing.

A fracture is distinguished from a dislocation by its preternatural mobility, its easily reduced but recurring displacement, and its crepitus, as contrasted with the preternatural rigidity, the deformity, difficult to reduce but remaining reduced, and the absence of crepitus of a dislocation. Further, in dislocation the bone, when rotated, moves as one piece, whereas in fracture it does not

so move; in dislocation the bony processes are felt occupying their proper relations to the rest of the same bone, while in fracture some of them present altered relations. In dislocation the head of the bone is found out of its socket, but in fracture it is felt in place. It is important to remember, moreover, that a fracture and a dislocation may occur together, and that the rubbing of a dislocated bone against an articular edge, when the joint has been roughened by inflammation, simulates crepitus.

Great contusion, by inducing extreme tumefaction, may mask characteristic deformity and obscure crepitus. When only a contusion exists, pain is apt to be widespread; but if a fracture has occurred, the pain is accentuated at some narrow spot. In many cases, before he can give a certain opinion, the surgeon must wait some days until the swelling has largely subsided. In such a case it is best to assume in our treatment that a fracture exists until the contrary is known. Combat swelling by rest, the use of evaporating lotions, and moderate compression.

In impaction the diagnosis is difficult. The moderate deformity is concealed by swelling; crepitus and preternatural mobility do not exist unless the fragments are pulled apart, and there is not necessarily much loss of function. A conclusion is reached largely by considering the nature, direction, and extent of the violence, the seat of the pain, and by a careful study of the most minute deformity. It is difficult to recognize fissures. They rarely present any evidence of their existence except a localized pain, and possibly a linear ecchymosis appearing after a few days.

In green-stick fractures the age, the deformity, and possibly crepitus during reduction help in the diagnosis, although in many cases no crepitus is obtained. Epiphyseal separations are diagnosticated by the age, the preternatural mobility, the pain, the swelling, the ecchymosis, the deformity, the situation of the injury, and the absence of crepitus or the presence only of a soft crepitus. It is important, however, to remember that an epiphyseal separation is sometimes incomplete, and even when it is complete there may be no displacement. In cases without displacement the x-rays will not enable us to make a diagnosis. In many cases of complete separation soft crepitus is obtainable; but in not a few cases it is not to be found. In incomplete separation crepitus is absent. If absent in complete separation, probably some tissue is between the lines. Fractures are often difficult to recognize when occurring in a group of bones (which are firmly joined by dense ligaments) like those of the carpus and tarsus, or in one of two parallel bones. There is not always a certainty that a fracture exists, and when, after a careful examination, there is still an uncertainty, do not prolong the efforts or use great force, but treat the case as a fracture until a cure ensues or the diagnosis becomes apparent.

In a child the diagnosis of fracture is sometimes difficult. Pain may be trivial. Children are liable to a form of fracture in which the periosteum is but slightly torn or is not torn at all, the disability and pain are often slight, and the fracture may be easily overlooked (Cotton and Vose).

We have recently had added to our resources a method of incalculable value in diagnosticating fracture; that is, the use of the force known as the x-ray or the Röntgen ray. We can look through a part with a fluoroscope and see the bones as shadows, or we can take a negative of the shadows

and print skiagraphs from it. This method is applicable even when the parts are swollen, and even when a limb is clothed or wrapped in dressings. It is possible to obtain a picture of a fractured skull after long exposure; fractured ribs and vertebræ can be detected; and the process is of the greatest use in detecting fractures of the limbs. It is not infallible. An epiphyseal separation may not be detected, and a slight angling of the plate may give a deceptive appearance of distortion. An *x*-ray picture, to be useful, must be taken by an expert and should be interpreted by a surgeon. This method should, if possible, be resorted to in doubtful cases.

Complications and Consequences.—Some of the consequences and complications of fractures are—sloughing of the soft parts, thus making the fracture compound; extravasation of blood, causing swelling or even gangrene; rupture of the main artery or vein of the limb; dislocation; edema from pressure of extravasated blood, from inflammatory exudation, from tight bandaging, from thrombosis, or, later, from the pressure of callus; stiffness of joints from synovitis with adhesion, from displaced fragments, or from intra-articular callus; stiffness of tendons from adhesive thecitis or from the pressure of callus; paralysis from traumatic neuritis, the pressure of callus upon nerve-trunks, or from division of a nerve; muscular spasm; painful callus; exuberant callus; embolism; fat-embolism; pulmonary congestion; gangrene; shock; septicemia; pyemia; tetanus; delirium tremens; urinary retention; extensive laceration of the soft parts; rupture of large nerves: and involvement of joints. A fracture may fail to unite, fibrous union or cartilaginous union only being obtained. An epiphyseal separation may arrest the future growth of the limb.

Repair of Fractures.—Simple Fracture.—In a simple fracture the bone is broken, the medullary contents are lacerated, the periosteum is torn, and the overlying soft parts are damaged to a considerable degree. The periosteum is stripped more or less from each fragment, but it is rarely completely torn through, an untorn portion known as the *periosteal bridge* remaining. The amount of blood effused is usually considerable, and it forms a decided prominence at the seat of fracture; it gradually gathers because of oozing, and soon clots. This clot lies in the medullary canal, between the fragments, under the periosteum at the ends of the fragments, and in the tissues outside of the periosteum. Very rapidly after the accident the damaged parts inflame (bone, endosteum, periosteum, and the torn periosseous structures). The inflammatory exudate enters into the blood-clot and the leukocytes eat up and destroy the clot. The clot is simply dead material and in no way contributes to repair. The cells of the damaged tissue proliferate and the young proliferating cells (fibroblasts) enter into the spaces in the blood and clot eaten out by the leukocytes. Finally the entire clot is replaced by fibroblasts and much of this cellular mass quickly becomes vascularized (granulation tissue).

The osteoblasts, which exist in the deeper layers of the periosteum and in the tissue of the medulla itself, begin to proliferate actively soon after the fracture has taken place. The fibroblasts have been formed by the proliferation of the ordinary connective-tissue cells, and the proliferating osteoblasts soon enter into and become widely distributed through this mass of fibroblasts. Some maintain that the fibroblasts themselves are directly

transformed into bone; other observers deny this, and think that all bone-formation comes from the osteoblasts. Osteoblasts may form bone directly, or may form cartilage first and then bone. When a fracture takes place, a bridge of periosteum is usually left untorn; and this bridge holds the fragments in contact at some point, just as a strap nailed to a trunk and also to its lid might hold these two objects in contact at some point. The new tissue about the periosteal bridge always becomes cartilaginous for a time; but the rest of the callus rarely shows the development of cartilage, and passes directly into bone. If, however, osteoblasts fail to proliferate with sufficient activity, the mass of granulation tissue becomes fibrous tissue; bone is not formed at all, or is very scantily formed; and fibrous union occurs. If the osteoblasts lack activity, but are more active than in the case just cited, they form cartilage extensively—but cartilage only; consequently, cartilaginous union occurs. During the process of the repair of a fracture the ends of the bony fragments are always softened, and some of the bone is absorbed by the osteoclasts. The osteoclasts are really large osteoblasts that have lost the power of producing bone and that furnish a secretion to absorb bone (the elder Senn). After bony union has been accomplished the osteoclasts absorb the superfluous callus. The mass of new tissue around and between the bone-ends is called *callus*. It will be observed that the name is applied successively to fibroblastic tissue, granulation tissue, fibrous tissue, and bone. Warren tells us that callus has no well-defined outline, and "involves not only the bone and periosteum, but also the connective tissue and some of the surrounding muscular tissue." Within a few days after the injury the inflammatory mass is much firmer than follows inflammation involving other structures, and the bone-ends are deeply imbedded in a dense mass.

During the second week the callus is greatly strengthened by the formation of dense fibrous tissue in and below the periosteum, of less dense fibrous tissue outside the periosteum, and of cartilage from the periosteal bridge. The newly formed tissue contracts decidedly. During the third week ossification begins at the points farthest from the fracture, and in the course of a short time (from three to six weeks) is complete. The mass of ossified callus, or new bone, is spindle-shaped and spongy.

The term *intermediate*, *definitive*, or *permanent* callus is used to describe the material which forms between the ends of the broken bone. The name *provisional* or *temporary* callus is given to the material within the canal (central callus) and external to the bone (ensheathing callus). The amount of provisional callus depends directly on the extent of separation and the amount of motion between the fragments. It is Nature's splint, and when the break is not well immobilized a large amount is formed. The greater the amount of motion, short of a degree sufficient to cause non-union, the larger the amount of provisional callus.

The ensheathing callus is after a time largely absorbed, and the central callus in the course of a long time may also be absorbed, with the restoration of the medullary canal, although this latter result is rare. An excessive amount of provisional callus may ossify nearby tendons, may unite two parallel bones (radius to ulna, tibia to fibula, a rib to its neighbors), may block a joint just as a stone in the crack of a door will block a door, or may

absolutely abolish a joint. Fragments, even if entirely detached, often unite, but they may be surrounded by provisional callus; sometimes they do not cause trouble, but sometimes suppuration takes place. It takes about one year for Nature to remove the temporary callus. The definitive or permanent callus after a time ceases to be porous and becomes very dense bone.

Compound fractures without much destruction or bruising of soft parts, if treated antiseptically, become at once simple fractures and unite as such. If the wound is not drained and asepticized and septic inflammation occurs, pus forms, and union by granulation is the best that can be obtained. Compound fractures by direct violence will not heal by first intention because of the loss of vitality of a large area of the soft parts.

Delayed union is usually due to imperfect approximation of the fragments. This imperfect approximation may result from failure to reduce the fracture (muscle, ligament, or synovial membrane being caught between

Fig. 206.—Ununited fracture of humerus (Horwitz).

the ends of the bone); the use of unsuitable splints; too tight application of bandages; and general causes of ill health, for instance anemia, scurvy, Bright's disease, rickets, syphilis, and pregnancy. In delayed union there is pain on passive motion; in non-union there is not. In delayed union there is loss of voluntary motion; in non-union there is power of voluntary motion (A. H. Tubby, in "Brit. Med. Jour.," Dec. 7, 1901). Delayed union is not non-union, but may eventuate in non-union.

Vicious or faulty union is union with great deformity. This occurs when no treatment has been employed, or when immobilization has been imperfect, or when deformity has not been reduced. It may arise because retentive dressings have been removed by the patient at too early a period, the callus yielding. In many cases it is slight and produces little or no pain or impairment of usefulness. In other cases it is pronounced and produces functional impairment or disastrous pressure on nerves or vessels. Vicious

union near a joint always impairs function. If there is pronounced vicious union the bone should be rebroken and set as a fresh fracture. In some recent cases the bone is broken by manual force and for several weeks after a fracture this can be easily accomplished. In older cases osteotomy should be performed.

Non-union of Fractures.—An ununited fracture is a fracture in which union is not effected at all or in which it is not brought about by bone. Non-union is especially common in fractures of the upper third of the femur and of the middle third of the humerus. The causes are local and constitutional. The *local causes* are (1) want of approximation of fragments (a frequent cause of want of approximation is interposition of soft tissues, especially muscle); (2) want of rest; (3) want of blood-supply (as seen in the heads of the humerus and femur, or when a nutrient artery is torn, or when a thrombus forms in a vein near the fracture); (4) defective innervation; (5) bone-disease; (6) the use of unsuitable splints; (7) tight bandaging. The *constitutional causes* are debility, scurvy, Bright's disease, syphilis, etc. Sometimes union fails to occur for no appreciable reason. In an ununited fracture the broken ends of the bone round off and the medullary canal of each fragment becomes closed by bone. The fragments may not be held together by any material, or they may be held by very thin and much-stretched fibrous tissue (*membranous* union), or by strong, thick, fibrous tissue (*ligamentous* or *fibrous* union). When the ends of the bones come together, are held by a fibrous capsule, and move on each other, there exists a *false joint* or *pseudarthrosis*. Such a joint may after a time secrete serous fluid for lubrication. In very rare cases a fracture once apparently soundly united may at a later period be obviously ununited, callus having been absorbed or broken.

Fig. 207.—Vicious union of fractured bones of the leg. View from inner side of limb (Horwitz).

Treatment of Fracture.—If a man is found in the street with a fracture, further injury must be prevented by applying, after cutting off the clothing over the fracture, some temporary support. If an ambulance or patrol-wagon cannot be obtained, move the patient by hand. If the lower extremity be involved, an improvised stretcher (a board or a shutter) is placed on the ground beside the patient, who is laid on the stretcher, the surgeon lifting the injured limb, and the patient is then carried to the hospital and carefully transferred to a fracture-bed, or, if taken home, to a small ordinary bed, several boards being placed transversely beneath a rather hard but even mattress. The temporary appliances are now removed and a diagnosis by the methods before given is proceeded with. After determining the nature

of the injury the fragments must be adjusted. This should, if possible, be done at once, because a fracture remaining unreduced may become compound, the fragments may injure important structures, and they are sure to cause intense pain. Reduction is easily effected during shock, as the muscles are in a state of relaxation. If there is great swelling, reduction may be impossible, and the part must then be supported, moderate cold, sorbefacients, and gentle pressure being used, ice and tight bandaging, which predispose to gangrene, not being employed. Set the fracture at the first possible moment. Velpeau's axiom was to reduce fractures at once, regardless of pain, spasm, or inflammation, as reduction is their cure.

If the patient is very nervous, if the pain is severe, or if rigid muscles antagonize the efforts of the surgeon, reduce the fracture under anesthesia. In some fractures (as those of the clavicle) adjustment is effected by altering the position, and in others (as those of the femur) by extension and counterextension; in some by tenotomy, and in some by kneading, bending, and coaptation. When extension is employed, always endeavor to get a point of counterextension. The extension is to be made on the broken bone (if possible, in the axis of the bone), is to be steady, and neither jerky nor violent. In some cases complete reduction is impossible. This may be due to spasm, to swelling, to the catching of soft parts between the fragments, to the existence of a loose fragment, to locking, or to impaction. An impaction by rotation can generally be released, but it is sometimes undesirable to unlock it. If the fragments cannot be adjusted without violence, retain them in the best attainable position, combat the antagonistic cause, and set them properly as soon as possible.

After adjusting the fragments maintain them in position by some retentive apparatus. Avoid pressure over joints or bony prominences and particularly guard against tight or improper bandaging. In fracture of a bone of a limb the circulation in the fingers or the toes must be observed as an index of circulation in the limb; hence leave those digitis exposed. A retentive apparatus should prevent the redevelopment of deformity, and not be itself productive of pain or harm. For the first few days of treatment of a simple fracture the dressing is removed every day, to make sure that deformity has not recurred, and if it does recur the fragments must at once be reset. The splints should be padded thoroughly, especially when over joints or bony prominences, and they should, if possible, fix the joints immediately above and below the break. A primary roller should *never* be used.

Some surgeons at once apply an immovable dressing. This proceeding is safe in simple fractures without much displacement or soft-part injury. This dressing is valuable in military practice, for the old and feeble whom we fear to put to bed, for the young who are very restless, and for the insane or the delirious. If, however, there is great deformity, much soft-part injury, or marked swelling, immovable dressings may induce sloughing, edema, gangrene or faulty union. In the above-named cases use splints for the first few days; then, if it is desirable, the immovable dressing can be applied. Plaster-of-Paris bandages are unsafe in very young children, and gangrene may occasionally result from their application. It is dangerous to keep old or feeble persons long in bed, as they are prone to develop bed-sores and hypostatic pulmonary congestion. The period for the artificial retention of the fracture varies with

the seat of the fracture and the age and the condition of the patient. Passive motion is to be made in most fractures in from two to three weeks, though it is sometimes made earlier to prevent ankylosis and sometimes later because of risk of non-union. Landerer strongly advocates massage, believing that it hastens union and prevents wasting. He applies it as soon as there is no danger of the callus bending (in from eight to fourteen days). Massage should not be used when great edema points to the possibility of venous thrombosis. The movements might break up a clot and cause fatal embolism.* Very early massage may cause fat-embolism. In fracture of the patella, Barker and many others believe in wiring, and some surgeons advocate the same procedure

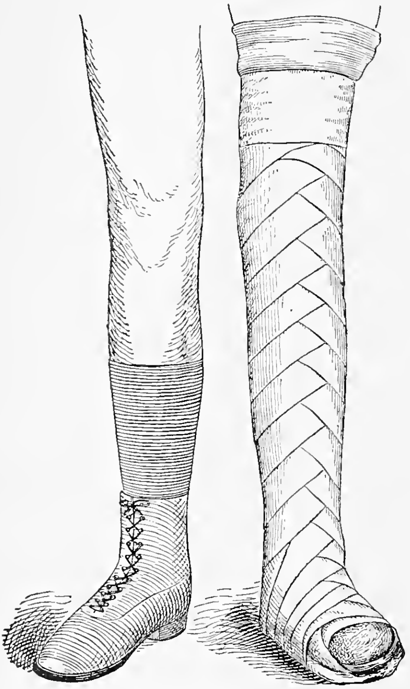


Fig. 208.—Ambulatory dressing of plaster-of-Paris for fracture of the bones of the leg (Pilcher).

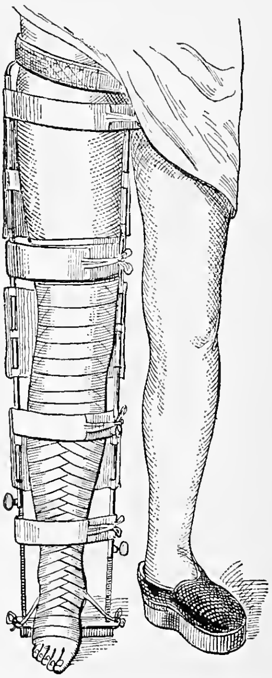


Fig. 209.—Ambulatory dressing apparatus for fracture of thigh (Harting).

in fracture of the clavicle, fracture of the tibia, and fracture of the upper third of the femur. If fragments cannot be approximated or retained by ordinary methods, an incision should be made, approximation effected, and the fragments retained by wire, a clamp, or a bone ferrule.

The plan known as the **ambulatory treatment** of fractures of the lower extremities has warm advocates. The ambulatory splint is an apparatus which enables a man to walk about a few days after receiving a fracture of the leg or thigh. It was devised by Hessing, a village carpenter near Augsburg. Its aim is not only to get the patient about on crutches, but also to cause him to use the limb. It is held that this plan of treatment greatly lessens the pa-

* Cerne's case, in "Normandie méd."; Bull. méd., 1895, No. 44.

tient's sufferings and actually favors union by the stimulation of walking. Bardeleben, in his report to the German Surgical Congress, gave the records of 111 fractures of the lower extremity thus treated (77 simple and 12 compound fractures of the leg; 17 simple and 5 compound fractures of the thigh). The patients were gotten about a few days after the accident, were able to attend to business, had excellent appetites, digested their food perfectly, slept well, and were saved from muscular atrophy. Pilcher has warmly advocated the method. It can be used in fractures as high up as the middle of the femur. The apparatus which we should employ in the ambulatory treatment reaches below the sole of the foot, and is supported firmly above the seat of fracture, the weight of the body being transferred from above the fracture to the firm pad below the sole of the foot on which the patient walks (Figs. 208 and 209). This appliance in a fractured thigh is put on about one week after the infliction of the injury. While the patient sits on the ischial tuberosities extension is made upon the leg. The seat of fracture is encircled with a thin plaster cast. The sole of the other foot is raised by a cork sole. Albers, when he treats a fractured thigh, uses plaster-of-Paris strengthened by bits of wood, running from *below* the sole of the foot to the iliac crest. Krause says in fracture of the ankle carry the dressing to the head of the tibia; in fracture of the leg carry it to the middle of the thigh; in fracture of the lower end of the femur carry it to the pelvis.* Bradford warmly advocates the use of Thomas's splint often combined with plaster-of-Paris.

Prevention and Treatment of Complications.—In every case of fracture of an extremity feel for the pulse between the periphery and the seat of injury in order to be sure the artery is not ruptured. If the soft parts are badly contused, try to prevent sloughing by employing rest and relaxation, and by applying heat. If superficial sloughing occur, treat antiseptically, remembering that even a superficial excoriation can admit bacteria which, carried by the blood or lymph, may infect the bones. If a slough leads down to the fracture, treat the case as a compound fracture. If there be great blood-extravasation the danger is gangrene, and after fracture of the lower extremity the foot of the bed may be elevated, or, better, after fracture of the upper or lower limb the extremity, to which splints and bandages are to be loosely applied, is to be raised and surrounded with hot bottles. If a bleb forms, it is to be opened with a clean needle and dressed antiseptically. If gangrene occurs, treat by the usual rules. Frequently after fracture of a bone blebs containing reddish serum form on the skin. The appearance of *blebs* when the circulation is good does not mean gangrene, and is not of any particular consequence. If blebs are due to gangrene, there are distinct symptoms of circulatory impairment.

Edema may be due to tight bandaging. If it is due to phlebitis, there is danger of pulmonary or cerebral embolism. In phlebitis elevate the limb, remove all constriction, and employ locally ichthyol ointment; do not use massage, and give stimulants by the mouth. In edema due to weak circulation or venous relaxation use daily frictions and firm bandaging. If the fracture involves a joint, carefully adjust the fragments, make passive motion early, and inform the patient that he will probably have a stiff joint.

A *dislocation occurring with a fracture* is reduced at once if possible. To do this, splint the limb and give ether, and try to reduce while the limb is managed with the splint as a handle. Allis is often able to reduce a dislocation

* Centralbl. f. Chir., vol. xxii, 1895.

accompanied by a fracture. He uses the untorn portion of periosteum as a hinge, pulls upon the lower fragment, and thus draws down the upper fragment and pushes it in place by manipulation. If this fails, it is best to incise and pull the separated end in place by the hook of McBurney and Dowd (Figs. 210–212); but some surgeons say, get the bones in the best possible position, set them, await union, and then treat the unreduced dislocation. A *rupture of the main artery* of the limb presents the symptoms of absent pulse below the rupture, a tumor which may pulsate, and possibly a whirring sound or an aneurysmal thrill and bruit. This condition demands that the surgeon should apply an Esmarch bandage, cut down upon the tumor, turn out the clot, and ligate each end of the vessel. *Rupture of the main vein* of a limb causes intense edema and calls for sutures, lateral ligatures, or complete ligation. If these measures fail after injury of vein or artery, or if gangrene appears, amputate at once above the seat of the fracture.

Fig. 210.—Fracture-hook (McBurney and Dowd).

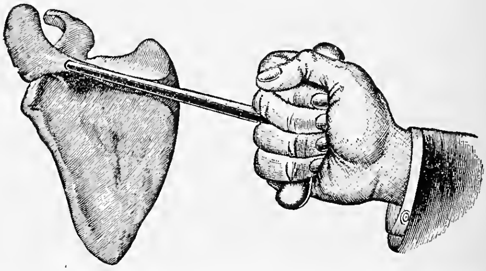


Fig 211.—Fracture-hook applied at base of acromion process (McBurney and Dowd).

Inflammation is to be treated by compression, rest, moderate cold, and later by a 50 per cent. ichthyol ointment. *Muscular spasm* requires morphin internally, firm bandaging, or even tenotomy. Fat-embolism is treated by stimulants and inhalation of oxygen, and possibly artificial respiration. Shock, delirium tremens, urinary retention, etc., are treated according to the ordinary rules of surgery.

Treatment of Compound Fractures.—It must first be decided, in a case of compound fracture of a limb, if amputation is necessary, and the x-rays are of great value in determining the condition of the bones in a crushed part. Amputation is demanded when the limb is completely crushed or pulpefied through its entire thickness; when extensive pieces of skin are torn off; when the main artery, vein, and nerve are torn through; and sometimes when there is violent hemorrhage from a deep-seated vessel or when an important joint is splintered. What is to be done is to some extent determined by the patient's age and general health. In a healthy young

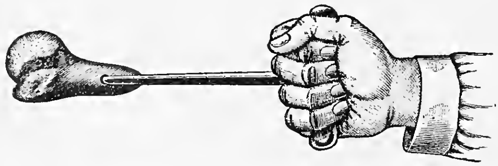


Fig. 212.—Fracture-hook inserted in displaced fragment (McBurney and Dowd).

person, if in doubt, give the limb the benefit of the doubt and try to save it; if the artery alone is ruptured, cut down upon it and tie both ends; if the vein alone is torn, suture it, apply a lateral ligature, or tie both ends; if the nerve is severed, suture it; if a joint is opened, drain and asepticize. If an attempt is made to save the limb, be ready at any time to amputate for gangrene, secondary hemorrhage (if re-ligation at original point and compression high up fail), extensive cellulitis, and profuse and prolonged suppuration.* When it is determined to try to save the limb, the part must be cleansed thoroughly by the antiseptic method (in no injuries is this more important). If a small portion of bone protrudes, cleanse the skin of the extremity and the protruding bone, push the spicule out a little more and cut it off. If a large piece of bone is protruded, it must not be cut away, but should be thoroughly disinfected, and after the skin wound has been enlarged should be returned into place. Hemorrhage requires a free incision to permit of ligation of bleeding points. In comminuted fractures, fragments which are completely broken off should be removed, but those which are only partially separated should be retained. In all cases a drainage-tube must be carried down to the seat of fracture, and in some cases a counter-opening must be made and the tube be pulled through the limb (Fig. 213).

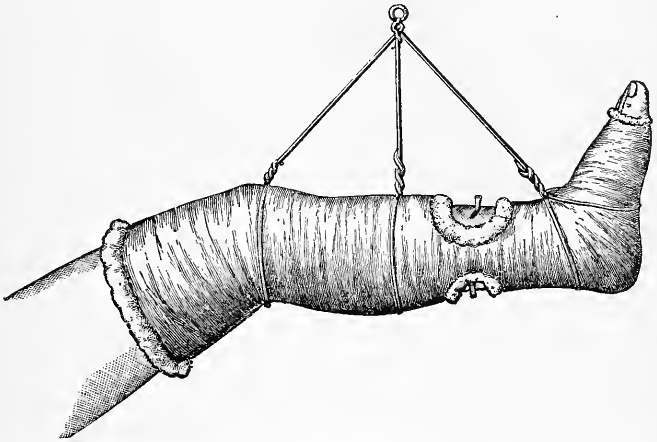


Fig. 213.—Fenestrated plaster-of-Paris dressing. Drainage tube pulled through limb.

After inserting the tube the wound is sutured, a plentiful antiseptic dressing is applied, and the extremity is dressed with plaster. The plaster can be applied over a narrow strip of wood, trap-doors or fenestra being cut in the plaster before it sets (the *fenestrated splint*) (Fig. 213). The wound is then covered with gauze and a bandage.

The bracketed splint is a better dressing than the one just described. After the wound has been dressed with gauze, plaster is at once applied over the ends of brackets (Fig. 214). The above methods not only immobilize the fractured bones, but keep the parts aseptic and afford easy access to the wound. The drainage-tubes are usually removed, if suppuration does not occur, in from forty-eight to seventy-two hours. The wound is treated as any other wound. In some compound fractures there is difficulty in retaining the fragments in apposition (lower end of femur, upper third of femur). In such cases the ends of the bone should be resected and the bones should be fastened together as in

* See Howard Marsh on "Fractures," in Heath's Dictionary of Practical Surgery.

a case of united fracture, with silver wire, aluminum wire, chromicized catgut, or kangaroo-tendon. In a *compound fracture of the patella* after free incision and disinfection, investigate to determine the gravity of the injury. In an ordinary case in which there are two or three fragments, open the joint, irrigate with saline fluid, drill the fragments, and fasten them with silver wire. Very small fragments should be removed. A tube is carried into the joint, the wound is sutured and dressed, and the limb is immobilized in extension. In a case of severe compound comminuted fracture of the patella, after disinfection, the loose piece should be removed and "the remaining portions made smooth with bone forceps and the sharp spoon." * The wound is only partially sutured, is drained and dressed, and the limb is placed on a straight posterior splint. If a fracture of a rib is compound internally, resect the rib; if it is compound externally, dress antiseptically.

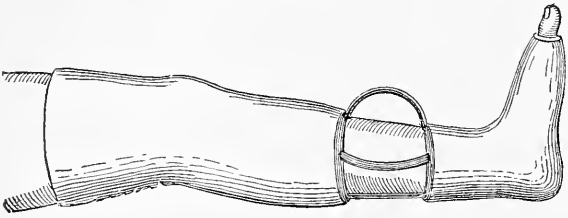


Fig. 214.—Bracketed plaster-of-Paris dressing.

Compound fractures may be followed by gangrene, sloughing, periostitis, septicemia, pyemia, osteomyelitis, necrosis, etc.

Treatment of Delayed Union and Ununited Fracture.—When delayed union exists, seek for a cause and remove it, treating constitutionally if required, and thoroughly immobilizing the parts by plaster. Orthopedic splints may be of value. Use of the limb while splinted, percussion over the fracture, and rubbing the fragments together, thus in each case producing irritation, have all been recommended. Blistering the skin with iodin or firing it has been employed. If the union be very long delayed, forcibly separate the fragments and put up the limb in plaster as we would a fresh break. If these means fail, irritate by subcutaneous drilling or scraping, or, better, by laying open the parts and then drilling and scraping at many places. Buechner advocates the induction of hyperemia by a constricting band, just as Bier induces congestive hyperemia in treating tuberculous areas. At first the constriction is permitted to remain but a short time, but the period is lengthened every day, until in a few days it remains almost continuously day and night. He claims that ten days of almost continuous application cures most cases. Helferich devised this method in 1887. In several cases I have thought that it did good, and I also administered thyroid extract to these patients. Lannelongue and Menard inject a 1 : 10 solution of zinc chlorid between the

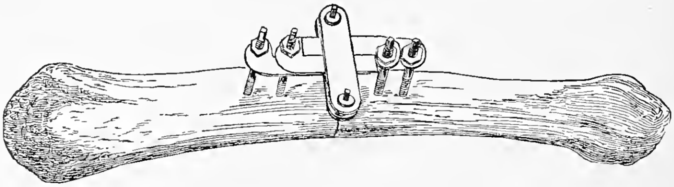


Fig. 215.—Parkhill's clamp for ununited fracture.

* Lilienthal's "Imperative Surgery."

fragments. Leaving acupuncture needles in for days is approved by some, and electropuncture is advocated by others. Cases of ununited fracture must be treated by excision of the bony ends and fibrous tissue, securing the fragments together by periosteal sutures, by pins, by screws and plates, by ivory pegs, by screws, by silver or aluminum bronze wire, by kangaroo-tendon, by Senn's bone-rings or bone-ferrules, or by chromicized catgut. Delorme makes an incision, removes bone-splinters and fibrous tissue, smooths off one end, forces this into the bored-out medullary canal of the other fragment, and sutures the periosteum. Gussenbauer's clamp will often give a good result, and was used for years by Billroth. Parkhill's clamp (Fig. 215) secures absolute immobility and is a very useful instrument (see Osteotomy for Ununited Fracture).

Treatment of Vicious Union.—If angular deformity results from faulty union, it can be corrected by moulding the part into shape while the callus is soft. If the callus has become hard, the bone can be refractured. If faulty union occurs with overriding, an osteotomy can be performed.

Special Fractures.—Nasal Bones.—The nasal bones, because of their situation, are often broken. The commonest seat of fracture is through the lower third, where the bones are thin and lack support. The fracture is usually compound externally or through the mucous membrane internally. The *cause* is direct violence. Displacement may not occur at all, but when present it arises purely from force, and never from muscular action, no muscle being attached to these bones. If the force is from the front, the nose is flattened; if from the side, it is deflected. Displacement is soon masked by swelling. Crepitus can sometimes be elicited by lightly grasping the upper part of the nose with the fingers of one hand and moving it gently below from side to side with the fingers of the other hand. Preternatural mobility is valueless as a sign, because of the natural mobility of the cartilages. Nose-breathing is difficult because of blocking of the nostrils by blood-clot. Diagnosis may be almost impossible when deformity is absent.

The complications that may be noted are cerebral concussion, brain-symptoms from implication of the frontal bone or cribriform plate of the ethmoid bone, and extension of the fracture to the superior maxillary or lachrymal bones. Emphysema of the root of the nose, the eyelids, and the cheeks is common, and means either a rent in the mucous membrane of Schneider or a crack in the frontal sinus. There may be much discoloration because of subcutaneous hemorrhage. Epistaxis is usual, and is recognized from the epistaxis produced by fracture of the base of the skull by the facts that the bleeding in the first condition is profuse, is, as a rule, soon checked, and is not followed by oozing of cerebrospinal fluid, whereas in the second condition it is profuse, continued, and followed by a flow of cerebrospinal fluid. Fracture of the bony septum occasionally complicates nasal fractures, and deviation of the cartilaginous septum often takes place. Suppuration may occur and necrosis of bone or cartilage may follow. The prognosis is usually good.

Treatment.—After cocainizing the nares a careful inspection should be made by means of a mirror and a light to determine if there is any injury of the septum. This point must be determined in order that the deformity of the septum may be corrected at the same time as is the deformity of the nasal bones. When there is no displacement, or when a displacement does not tend to be reproduced after reduction, employ no retentive apparatus of any kind. Order

the patient not to blow his nose for ten days and syringe it daily with a solution of bicarbonate of sodium. If deformity be noted, correct it at once, as the bones soon unite in deformity. If the attempts at reduction are very painful, or if the subject be a child, a woman, or a nervous man, give ether to obtain primary anesthesia. Reduction is effected by a grooved director or steel knitting-needle wrapped in iodoform gauze and passed into the nostril; the fragments are lifted with this instrument, and the fingers externally mould them into place. A rubber dilator can be used in reduction. This is pushed into the nose and inflated by air or water. If the septum is deviated and cannot be pushed in place by a metal sound, it must be twisted into place by means of septum forceps. If bleeding is moderate, check it with cold; if severe, by plugging. "For fractures high up with displacement, gauze packing carried well up will be required to retain the elevated bones. For lower deviations the Asch tube will be needed" (Scudder, on "The Treatment of Fractures"). A hollow vulcanite plug is inserted in each nostril and the nose is moulded into correct shape over the plug. The patient breathes through the hollow plug. A thread runs from each plug and is fastened to the cheek by adhesive plaster. Once or twice a day the plugs are removed, cleaned, and greased with iodoform ointment. The nose is cleared, and the plugs are reinserted. If flattening tends to recur, pass a Mason pin (Fig. 216) just beneath the fragments, through the line of fracture and out the opposite side. Steady the fragments by a piece of rubber externally caught on each end of the pin, or with figure-of-eight turns around the ends with silk. Leave the pin in place for five days. The instrument of Mason is a sharp, strong, nickel-plated pin, with a triangular point.

Fig. 216.—Mason's pin.

If lateral deformity tends to recur, hold a compress over the fracture or fix a moulded-rubber splint over the nose by a piece of rubber plaster one and a half inches broad and long enough to reach well across the face, and use compression for ten days. In neither of the above cases is the nose to be blown, and in both cases it is to be syringed once or twice a day. In fractures rendered compound by tears in the mucous membrane irrigate with normal salt solution or boracic-acid solution, holding the head so that the solution will not run into the mouth; plug with iodoform gauze around a small rubber catheter, which instrument permits nose-breathing; carefully remove the gauze daily and syringe. In fractures compound externally cleanse antiseptically externally, and dress with a film of cotton soaked in iodoform collodion or compound tincture of benzoin, or apply sterile gauze. Fractures of the bony septum, if showing a tendency to reproduction of deformity, require packing as above explained or the use of a special splint within the nostrils (Fig. 217), or the application of vulcanite plugs, so made that the patient can breathe through them, and that threads can be attached to them. Fractures of the nasal cartilages are to be

Fig. 217.—Jones's nasal splint.

pinned in place. Fractures of the nose are entirely united in from ten to twelve days.

Fractures of the Lachrymal Bone.—The lachrymal bone may be broken when the nasal bones, a superior maxillary bone, or the lateral plate of the ethmoid are fractured, and union is solid in from three to four weeks. The question of how much deformity is to be expected is always uncertain, and in not a few cases obstruction of the nose follows fracture because of damage to the septum.

Treatment.—Treat the chief injury, which is the fracture of the other bone or bones. Maintain the patency of the lachrymal duct by frequently passing a clean probe.

Fractures of the Superior Maxillary Bone.—Although a fragile bone, the superior maxillary is rarely broken except through the alveolar border. It may be broken by transmitted force from blows on the chin, or on the head when the chin is fixed; but direct violence is the usual cause. The wall of the antrum may be crushed in. Comminution is the rule, and the injury is often compound. These fractures induce great swelling, pain, and inability to chew. Mobility and crepitus may be detected. Deformity is due to the breaking force, and not to the action of any muscle. When a portion of the alveolar arch is fractured, as may occur in pulling teeth, the small fragment is depressed backward, and there exist irregularity of the teeth (some of which may be loosened) and inability to chew food. Fracture of the nasal process is apt to injure the lachrymal duct. When the antrum is broken in there are great sinking over the fracture, depression of the malar bone, and emphysema. Transverse fracture of the upper part of the body of the bone may cause no deformity. The force required to break the superior maxillary bone is so great that fractures of other bones almost certainly occur, and concussion of the brain not infrequently exists. Injury of the infra-orbital nerve is not unusual, causing pain, numbness, or an area of anesthesia involving one-half of the upper lip, the alæ of the nose, and a triangle whose base is one-half the upper lip and whose apex is the infra-orbital foramen. There is also loss of sensation in the gums and upper teeth of the injured side. Fractures of the superior maxillary bone occasionally induce fierce hemorrhage from branches of the internal maxillary artery; and if this occurs, watch for secondary hemorrhage (these vessels being in firm canals).

Treatment.—If the fracture does not implicate the alveolus, or if no deformity exists, apply no apparatus, but feed the patient on liquid food for four weeks. Reduce deformity, if it exists, by inserting a finger in the mouth. If the antrum is broken in, put the thumb in the mouth and push the malar bone up and back. In certain cases of deformity make an incision at the anterior border of the masseter muscle, insert a tenaculum or aneurysm needle, and pull the bone into place (Hamilton). If the malar bone or malar process is driven into the antrum, Weir tells us to incise the mucous membrane above and external to the canine tooth of the upper jaw, break into the antrum with a bone-gouge, insert a steel sound, lift out the malar bone, and pack the antrum with gauze. Loose teeth are not to be removed; they are pushed back into place and held by wiring them to their firmer neighbors. Hemorrhage is arrested by cold and pressure. If hemorrhage is dangerously profuse or prolonged, tie the external carotid.

If the line of the teeth, notwithstanding the wiring, is not regular, mould on an interdental splint. The usual splint for the upper jaw is the lower jaw held firmly against it by the Gibson, the Barton, or the four-tailed bandage. There is a great amount of dribbling of saliva during the treatment, and a dressing must be used to catch this fluid. Every day remove the bandage and dressing, and wash the face with ethereal soap. The patient, who is ordered not to talk, is to live on liquid food administered by a nasal tube or by pouring it into the mouth back of the last molar tooth by means of a tube or a feeding-cup. Never pull a tooth to obtain a space; but if a tooth is lost, utilize the vacant space for this purpose. After every meal wash out the mouth with peroxid of hydrogen followed by chlorate of potassium, boracic-acid or normal salt solution, and thus prevent foulness and the digestive disorders it may induce. Dispense with the dressings in six weeks, and let the patient gradually return to ordinary diet.

In fractures compound externally do not remove fragments, antisepticize, arrest bleeding as far as possible by ligature, by pressure, or by plugging, wire the fragments if feasible, dress with gauze, and wash the mouth with great

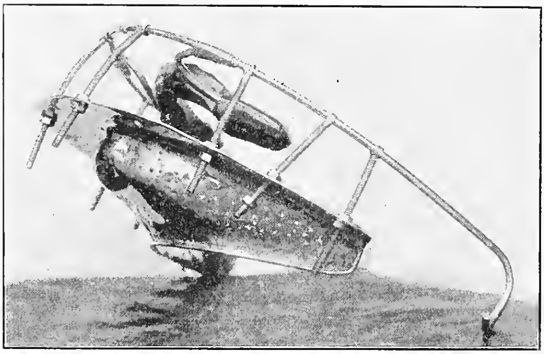


Fig. 218.—Hard-rubber splint; wire arms and chin-piece held together by metal rods and nuts.

frequency. Fractures compound internally are treated as simple fractures, except that the mouth is washed more frequently.

The **malar bone** is rarely broken alone. Hamilton says no uncomplicated case is on record. The malar is a strong bone resting on a fragile support, and hence it may become a wedge to break other bones and yet itself be unfractured. The *cause* of fracture is violent direct force. A fracture of the orbital surface of this bone causes subconjunctival hemorrhage like that encountered in fracture at the base of the skull, and may produce irritation of the infra-orbital nerve. Protrusion of the eye may result either from hemorrhage or from crushing in of the malar bone. There is a hollow below and to the inner side of the orbit. Occasionally the line of fracture is detectable. but mobility and crepitus are very rarely discoverable. Chewing is apt to cause pain, and often the motions of the lower jaw are limited, the coronoid process being pressed upon by a depressed malar bone, an associated fracture of the zygoma, a blood-clot or swollen tissue. (See Scudder, on "The Treatment of Fractures.")

Treatment.—If no deformity exists, there is practically nothing to be done. If deformity exists, try to correct it as in fractures of the superior maxillary bone. If correction is impossible by ordinary methods and the movements of the lower jaw are impeded by the displaced bone, make a small incision and through this insert an instrument and endeavor to lift the bone into place. As these cases are almost invariably complicated by fracture of the upper jaw, they are treated in the same manner as the latter injury. The union is complete in three weeks.

Fractures of the zygomatic arch are very rare. The *causes* are (1) direct violence; (2) indirect force (from depression of the malar); and (3) forcing foreign bodies through the mouth. Direct violence is the usual cause. Direct violence causes inward displacement, and indirect force may cause outward displacement. The usual seat of fracture is at the smallest portion of the process—that is, on the temporal side of the temporomalar

Fig. 219.—Front view of splint (figure 218), with mouth closed (Moriarty).

suture (Matas). The symptoms are pain, ecchymosis, swelling, displacement, and difficulty in moving the jaw (because of injury to the masseter muscle).

Treatment.—In simple fracture give ether and try to push the arch in place. Many surgeons do not make an incision, as depression will do no harm and the functions of the jaw will be restored. Simply dress with a compress, adhesive strips, and the crossed bandage of the angle of the jaw. Union will take place in three weeks. Matas* advises operation. An anesthetic is administered, and the parts are asepticized. A long semicircular Hagedorn needle is threaded with silk, is entered one inch above the middle of the displaced fragment, is passed well into the temporal fossa, and is made to

* New Orleans Med. and Surg. Jour., Sept., 1896.

emerge half an inch below the arch. The silk is used to pull a silver wire around the fracture, and this wire is employed to pull the bone into position. A firm pad is applied externally and the wire is twisted over the pad. Antiseptic dressings are applied, and on the ninth or tenth day the wire, splint, and dressings are removed permanently. I have employed this plan in two cases with perfect satisfaction.

Fractures of the inferior maxillary bone may, and most usually do, affect the body, although they occasionally occur in the rami. Any part of the body may be fractured, the most usual seat being near the canine tooth or a little external to the symphysis (Pick). A portion of alveolus may be broken off. In fractures of the ramus either the angle, the condyloid neck, or the coronoid process may be broken. In fractures of the body the posterior fragment generally overrides the anterior. Fractures of the lower jaw are often multiple and are almost always compound, because the oral mucous membrane and alveolar periosteum are torn. The *cause* is usually direct vio-

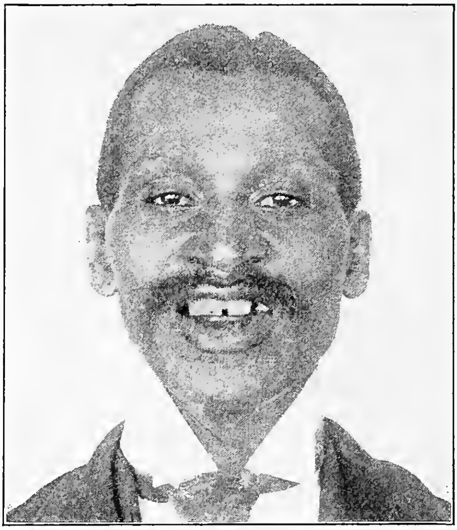


Fig. 220.—Hard-rubber splint in position, upper teeth resting upon it (Moriarty).

lence. Indirect violence (lateral pressure) may fracture the body anteriorly. Fractures near the angle are always due to direct violence. Indirect violence may fracture the condyle (falls on the chin), and so may direct violence. Fractures of the coronoid process are very rare, and they arise from great direct violence (usually a gunshot-wound or some other penetrating force).

Symptoms.—In fracture of the body preternatural mobility and crepitus generally exist. The gum over the fracture swells rapidly and decidedly. There is bleeding because of laceration of the gum; saliva dribbles constantly; after two or three days some of the cervical lymph-glands enlarge; when the fracture is open through the mucous membrane suppuration is usual; the odor of decomposition soon becomes marked; the patient supports the jaw with the hand; great pain exists (possibly from injury of the nerve); and deformity

is present, shown by inequality of the teeth if the fracture is anterior to the masseter, the anterior fragment going downward and backward and the posterior fragment going upward and forward. The downward displacement is due to muscular action (action of the digastric, geniohyoid, and genio-hyoglossus). The backward displacement is due to the violence. The temporal muscle draws the posterior fragment upward and to the front. In fracture of the neck of the condyle the jaw is drawn toward the injured side, and the condyle is pulled inward and forward by the action of the external pterygoid muscle. In fracture of the coronoid process the temporal muscle pulls the small fragment upward.

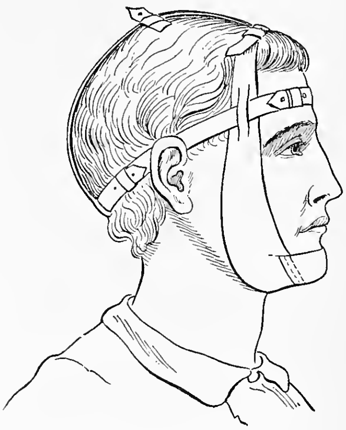


Fig. 221.—Hamilton's bandage.

Complications.—The complications are—digestive disorders and diarrhea from swallowing foul discharges; loosening of the teeth; lodgment of loosened teeth between the fragments; bleeding (usually only oozing from the gum, but there may be hemorrhage from the inferior dental artery); and suppuration. Necrosis may follow these fractures, an abscess of the neck may develop, or a sinus may form.

Treatment.—Remove a tooth if it lies between the fragments, but replace it in its socket after reducing the fracture. Correct deformity with great care and be sure to bring the teeth into normal alinement. As a rule, push loose teeth into place and put back detached ones; but occasionally a tooth obstinately prevents perfect approximation, and if it does it must be removed. Wash the mouth with hot water to clean it and to check bleeding. If bleeding is very severe, compress the carotid artery for a time. The fracture can be dressed with a pad of lint over the chin and Hamilton's four-tailed bandage (Fig. 221). A common plan is to take a splint of pasteboard, felt, or gutta-percha; pad it lightly with cotton, mould it to the part, and hold it in place with a Barton or a Gibson bandage. If apposition of the fragments cannot be maintained by the above methods, fasten the teeth together with wire, wire the fragments together, or have a dentist apply an interdental splint (Figs. 222, 223). Fracture of the lower jaw can often be most satisfactorily treated by Angle's bands. These bands are of great value in complicated cases, in which two or more fractures exist. Each band consists of thin metal and a screw and a nut to fit the screw. The band is adjusted around a firm tooth and a nut is applied so as to hold the band tightly. Several bands are placed

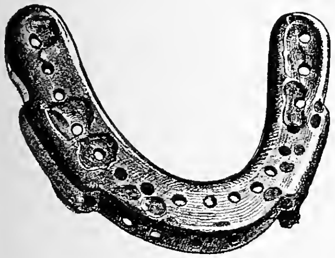


Fig. 222.—Vulcanite splint with boxes vulcanized on each side. If the jaw is fractured in the region of the molars, considerable pressure is required to get the parts in position; therefore it is best to vulcanize on to the sides of the vulcanite splint boxes into which wire arms can be inserted (Pilcher).

upon teeth in both jaws. Silver wire or silk is thrown around the pins of the bands so as to catch, and the jaws are thus held firmly together. The patient is to be fed on liquid food (see Fracture of the Upper Jaw), the mouth is to be washed frequently with peroxid of hydrogen, followed by boric-acid solution or normal salt solution, and the dressings are to be changed every second day. The union should be complete in five weeks. Though these fractures are usually compound, they do not endanger life.

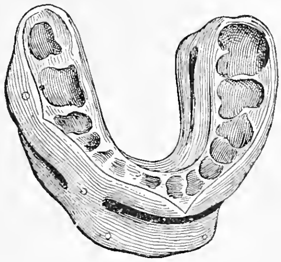


Fig. 223.—Interdental splint.

Fractures of the Hyoid Bone.—These fractures are uncommon injuries, and are caused by hanging, by throttling, and by falls in which the neck strikes some obstacle. If the bone breaks by throttling, it is its body which fractures (indirect force). Fractures by muscular action are most unusual.

Symptoms.—The symptoms are—a sensation of something breaking; bleeding from the mouth if the mucous membrane be lacerated; pain, which is worse on opening the jaws or on moving the head or tongue; difficulty in swallowing; muffled, hoarse voice or aphonia; swelling, and frequently ecchymosis, of the neck. There are observed occasionally, though rarely, harsh cough and dyspnea, irregularity of bony contour, and crepitus. Always look into the mouth and see if there can be detected ecchymosis or laceration of the mucous membrane or projection of a bony fragment. The displacement is due to the middle constrictor of the pharynx contracting. A fracture of the hyoid bone may destroy life.

Treatment.—For dyspnea, be ready to perform intubation or tracheotomy at a moment's notice. Edema of the glottis is a great danger. Try to restore the fragments with one hand externally and with a finger in the mouth. Put the patient to bed and have him lie back upon a firm rest so that his shoulders are elevated. His head is to be placed between extension and flexion, a pasteboard splint or collar is moulded on the neck, and a bandage is applied around the forehead, neck, and shoulders to keep the head immobile. The patient must not utter a word for a week; he must at first be fed by enemata, and then for some time on liquid diet, which is given through a tube early in the case. Endeavor to control the cough by opiates. A fractured hyoid bone requires about four weeks to unite.

Fractures of laryngeal cartilages are caused by direct violence, as throttling, blows, or kicks. They are rare in young persons, and are commonest when the cartilages have begun to ossify. They are very grave injuries, death tending to occur from obstruction to the entrance of air.

Symptoms.—The symptoms, which are severe, are pain, aggravated by attempts at swallowing or speaking; swelling, ecchymosis it may be, and emphysema of the neck; cough; aphonia; intense dyspnea; and bloody expectoration if the mucous membrane is ruptured. There can be detected inequality of outline (flattening or projection) and perhaps moist crepitus. The usual seat of the injury is the thyroid cartilage.

Treatment.—Cases without dyspnea require quiet, avoidance of all talking,

feeding with a stomach-tube, the application of compresses and adhesive strips over the fracture, and the use of remedies to quiet cough. The surgeon must be ready to operate at any moment. In most cases dyspnea exists, due to projection of the fragments or submucous extravasation. When there is dyspnea, emphysema, or spitting of blood, at once practise intubation, or, if unable to do this, open the larynx or trachea below the seat of fracture. If laryngotomy or tracheotomy is performed, try to restore to proper position displaced fragments. If the fragments will not remain reduced, introduce a Trendelenburg cannula or a tracheotomy-tube, and pack gauze around it. Take out the packing in four days, and remove the tube as soon as the patient breathes well, when the opening may be allowed to close. In these cases feed with a stomach-tube and keep the patient absolutely quiet. Union takes place in four weeks.

Fractures of the Ribs.—The ribs, owing to their shape, elasticity, and mode of attachment, readily bend and as readily recover shape, and thus withstand considerable force without breaking. Notwithstanding these facts, the situation of the ribs so exposes them that in 16 per cent. of all cases of fractures noted by Gurlt these bones were involved. In children fracture of a rib seldom occurs and is usually incomplete; it is common in adults and the aged, and in them is generally complete. It is more frequent among men than among women. The ribs commonly broken are from the fifth to the ninth, the seventh being the one that most frequently suffers. Fracture of the first rib alone is an excessively rare accident. The eleventh and twelfth ribs are seldom broken. A rib may be broken in several places, and several ribs are often broken at the same time. Fracture of a single rib is not nearly so common as fracture of several ribs. These fractures may be compound either through the skin or through the pleura, a damaged lung permitting pneumothorax. Compound fractures are very rare, however, except from bullet-wounds.

Causes.—*Direct* force, as buffer accidents, kicks, blows with heavy instruments, or being jumped on while recumbent, may produce these injuries. A fracture from direct violence occurs at the point struck, and the ends, projecting inward, may damage a viscus. *Indirect* force, as great pressure or blows which exaggerate the natural bony curves, tends to produce fractures near the middle of the ribs or in front of their angles and to force the ends outward. A number of ribs are apt to be broken. Muscular action, as in coughing or parturition, occasionally, but very rarely, is a cause.

Symptoms.—In connection with the history of the accident the symptoms are: acute localized pain (a stitch) on breathing, increased by pressure over the seat of pain, pressure backward over the sternum, cough, and forcible inspiration or expiration; respiration is largely diaphragmatic, the patient endeavoring to immobilize the injured side; cough is frequent and is suppressed because of pain. Crepitus is often but not invariably found. The surgeon seeks for it, first, by resting the palm of his hand over the seat of pain while the patient takes long breaths; second, by placing a thumb before and one behind the seat of pain and making alternate pressure; and third, by auscultation. It should be remembered that incomplete fractures are the rule in children; hence in them do not expect crepitus. Deformity is usually trivial unless several ribs are broken, because shortening cannot occur and the

intercostal attachments prevent vertical displacement. Preternatural mobility may occasionally be elicited, when the region is not deeply covered with muscles, by pressing on one side of the supposed break and observing that a part of, and not the entire, rib moves. If air gathers in the subcutaneous tissue and there is no wound of the surface, it is proof of rib fracture with lung damage. In such a case the lung has been penetrated by a fragment, and air has been forced out into the tissues. This condition is recognized by great and growing swelling, which crackles when touched. Such a collection of air is known as *cellular emphysema*. Bloody expectoration suggests lung injury; bloody expectoration and cellular emphysema, without an external wound, prove injury of the lung. A simple, uncomplicated case of fracture of a rib or ribs in a young person gives a good prognosis.

The *complications* are: additional injury, making the fracture externally or internally compound; laceration of the pleura, pericardium, heart, lung, diaphragm, liver, spleen, or colon; rupture of an intercostal artery; hemothorax; cellular emphysema; pulmonary emphysema; pneumothorax; pyothorax; traumatic pleurisy; pneumonia; bronchitis; congestion or edema of the lungs.

Treatment.—In an uncomplicated case the patient is not kept in bed, as breathing is easier when erect than when recumbent. Angular displacement outward is corrected by direct pressure. Displacement inward is soon corrected, as a rule, by the expansion of ordinary respiratory action; but if it is not thus corrected, etherize, the deep breathing of the anesthetic state almost always succeeding. If ether fails, and dangerous symptoms come on, incise under strict antiseptic precautions, elevate, and drain, or sometimes resect a portion of the rib.

After correcting any existing deformity immobilize the injured side. Direct the patient to raise his arms above his head, to empty his chest of air by a forced expiration, and to keep it empty until a piece of rubber plaster (two inches wide) is forcibly applied seven or eight inches below the fracture and from the spine to the sternum. The patient is now allowed to take a breath and is directed to empty the chest again, another piece of plaster being applied, covering the upper two-thirds of the width of the first strip. This process is continued until the side is strapped well above and well below the fracture (Pl. 6, Fig. 13). Over the plaster light turns of a spiral bandage of muslin are carried, or a figure-of-8 bandage of the chest is applied, the turns crossing over the seat of injury. About once a week the plaster is removed and fresh pieces applied after rubbing the chest with soap liniment, drying, and anointing excoriations with an ointment of oxid of zinc. The dressing is worn for three or four weeks. The patient avoids cold, damp, and draughts. The diet must be nutritious but non-stimulating, and any cough should be treated by opiates and expectorants. A person with this injury who has reached the age of sixty must take stimulant expectorants (ammonii carb., gr. x, in infus. senegæ, ʒss, *t. i. d.*) or employ a steam-tent several times a day. The old method of treatment, in which the chest was included in a forcibly applied broad rib-roller, is not to be used except as a temporary expedient; it compresses the entire chest, causes pain and dyspnea, and tends to loosen and slip.

Fracture of the ribs complicated with visceral injury is highly dangerous,

and requires confinement to bed. The treatment is that of the visceral injury. If there be bloody expectoration, apply adhesive strips as above indicated, put the patient to bed reclining on a bed-rest, keep him quiet, subdue the circulation, and employ opium, diaphoretics, and expectorants (a good mixture consists of squill, ipecac, ammonium acetate, and chloroform; opium is given separately). Inflammations of the lung or the pleura, fortunately, are apt to be localized, and are treated as are ordinary inflammations of these parts. If signs of pulmonary injury are severe from the start or become worse under medical treatment, incise, resect a rib, arrest hemorrhage, and drain the pleura. In laceration of an intercostal artery incise and try to ligate; if unable to ligate, resect a rib and apply a ligature. If the signs point to internal bleeding, resect a rib, search for the bleeding point, and ligate. Emphysema usually soon disappears; but if it does not, make many small incisions in the cellular tissue, dress antiseptically, and employ pressure. When there arises a sudden attack of dyspnea, which is prone to happen in these cases, and in which the face becomes blue, the heart labors, and suffocation seems imminent, bleed the patient almost to syncope.

Fractures of the costal cartilages are not common, even in the aged. Such fractures occur either through the cartilages or through their points of junction with the ribs. These injuries generally arise from direct violence, the cartilage of the eighth rib being most prone to suffer. Indirect force (such as a blow upon the shoulder) is occasionally the cause, but when it is the cause some other injury besides the fracture of the cartilages is apt to be noticed. Muscular action is a possible cause.

Symptoms.—Displacement is often absent; but if present, it is forward or backward of either fragment, and is due chiefly to the force of the injury, but partly, it may be, to muscular action. When displacement is absent, crepitus will not often be found; in fact, crepitus is usually absent in these injuries. Localized pain, swelling, and ecchymosis are noted. Preternatural mobility may or may not be detected. Union by bone is to be expected.

Treatment.—If displacement exists, try to reduce it. If the fragment is displaced backward, reduce by deep inspirations; if the fragment is displaced forward, reduce by pulling back the shoulders. In this attempt failure is the rule, and the surgeon may then adopt Malgaigne's expedient of applying a truss over the projection for a day or two. Dress and treat the case as if a rib were broken, removing the dressings in four weeks.

Fractures of the Sternum.—The sternum may be broken, along with the ribs and spine, from great violence. Fractures of the sternum alone are infrequent, because the bone rests on a spring-bed of ribs. Fractures of the sternum may be simple or compound, complete or incomplete, single or multiple. The most usual injury is a simple transverse fracture at or near the gladiomanubrial junction, at which point dislocation may also occur. Both fracture and separation of the ensiform cartilage are very rare. The sternum may be broken along with the ribs or clavicle.

Causes.—These are: *direct* force, as by a fall of an embankment or of a wall, by a car-crush, or by the passing of a cart-wheel over the body; *indirect* force, as by a fall upon the head, thus driving the chin against the chest; by a fall upon the feet, the buttocks, or the shoulder; by forced flexion or extension of the body over an edge or angle (as may occur during labor-pains).

Symptoms.—In fracture of the sternum displacement is not always present, but when it does occur the lower fragment is apt to pass forward; displacement may, however, be transverse or angular, or there may be overriding. The posterior periosteum, which rarely tears, limits displacement, but some deformity can, as a rule, be detected. The history of the nature of the accident has a valuable bearing upon the question of diagnosis. The position assumed by the patient is with the head and body bent forward, as attempts to straighten up cause much suffering. There is fixed and localized pain, increased by deep respiratory action, by body-movements, or by cough. Crepitus is sought for by auscultation and by placing the hand over the injury and directing the patient to make quick respirations. Mobility may become manifest on external pressure, during respiration, or while attempts are being made to bring the body erect. Respiration in these cases is usually much interfered with. It is not important to separate diagnostically diastasis from fracture.

Complications.—Other fractures generally complicate fracture of the sternum, and laceration of the pleura or pericardium and hemorrhage into the anterior mediastinum may exist. Abscess of the mediastinum and necrosis of the sternum may appear as late consequences. The *prognosis* is good in uncomplicated cases.

Treatment.—The deformity attending fracture of the sternum is to be corrected, if possible, by external pressure. If overriding is found, effect reduction by bending the body back over a firm pillow and ordering the patient to respire deeply; if this method fails, give ether and then bend the body backward. The deformity, after reduction, tends to recur, but the bones unite well even in deformity, and no great harm results. The fragments need not be cut down on or be hooked up unless there be internal injury. After reducing the deformity, cover the front of the chest with adhesive strips extending laterally from one axillary line to the other, and covering a region from above the fracture down to the ensiform cartilage. Place over this covering an anterior figure-of-eight bandage of the chest. In some cases, where deformity recurs after reduction, a circular bandage of the chest is applied and the shoulders are pulled strongly back with a posterior figure-of-eight bandage. The plaster is to be reapplied once a week. Some surgeons treat these cases by means of a large compress held by adhesive plaster and a broad tight roller.

The patient goes promptly to bed, and reposes erect. or semi-erect, on a bed-rest. This position favors easy respiration and antagonizes the tendency to displacement. The diet should be light, nutritious, and non-stimulating. Convalescence is established in four weeks, and the plaster should be permanently removed in five weeks. When the ensiform cartilage is so bent in as to cause intense pain or to injure the stomach, it should be exposed by incision and resected. Edema of the skin and fever, if they appear, indicate pus, in which case an incision should be made at the edge of the sternum and the pus-cavity should be irrigated and drained.

Fractures of the Pelvis.—In some of the indicated fractures serious injury of the pelvic contents is apt to be found.

Fractures of the False Pelvis.—Fractures of this region are seldom dangerous unless comminuted. There may be fracture of the iliac crest

or of the anterior superior spine, or the line of fracture may traverse the entire length of the flanged-out ilium, or the bone may be comminuted with the association of grave visceral damage. The anterior superior and posterior superior spines may be broken off.

Causes.—The cause of fracture of the false pelvis is generally violent *direct* force, as the passage of a wagon-wheel, the fall of a wall, the kick of a horse or mule, or the force of car-crushes. Violent contraction of the rectus muscle may tear off the anterior inferior spine of the ilium.

Symptoms.—In fracture of the false pelvis the history of violent force is noted. The patient leans toward the injured side. Pain exists, which is aggravated by movements (particularly by bending forward), by coughing, or by straining to empty the bowels or the bladder. Ecchymosis and swelling are manifest. Crepitus and preternatural mobility are detected by moving the iliac crest. Deformity is very rarely present. Cases uncomplicated by visceral injury make good recoveries.

Complications.—The fracture may be, but rarely is, compound, as the parts are well protected with muscles. The colon may be injured when comminution has taken place.

Treatment.—If there are symptoms of injury of the colon, perform laparotomy, search for the injured region, and suture it. In treating an ordinary fracture of the false pelvis put the patient on a fracture-bed, raise the shoulders, and apply a canvas binder about the pelvis, or encase the pelvis with broad pieces of rubber plaster, or employ the belt or girdle. The pressure of the binder, girdle, or plaster must not be so great as to force the fragment of ilium inward. Place the knees over two pillows so as to semiflex the legs and thighs, and tie the knees together. To restrain thigh-movements it may be necessary to encase a restless patient with splints or bind him to sand-bags. If the pelvic binder displaces the fragments or causes pain, abandon it and trust to position. If the fragment cannot be retained in place, wire it. The dressings can be removed in six weeks, and the patient is allowed to get up in eight weeks. In simple, uncomplicated fracture of the false pelvis the prognosis is good. In compound fractures of the false pelvis asepticize, drain and dress, put on a binder, and direct the same position to be maintained as for simple fractures.

Fractures of the True Pelvis.—The most usual seat of these fractures is through the obturator foramen, the ascending ischial and horizontal pubic rami being broken. A fracture may occur near the symphysis pubis, the symphysis may be separated, a break may run near to or into the sacroiliac joint, the same fracture may occur on each side of the body of the pubis, and there may be multiple fractures. Fractures of the acetabulum and of the tuberosity of the ischium may occur. Before the seventeenth year the innominate bone may be broken into its three anatomical segments. Fractures of the true pelvis are highly dangerous because of the damage which is apt to be inflicted on the pelvic contents. There may be rupture of the bladder or membranous urethra and injury of the vagina, the rectum, the uterus, or the small gut. The *cause* of pelvic fracture is violent force, direct or indirect. Front force tends to produce direct, and side force indirect fracture. The acetabulum may be broken by falls upon the feet.

Symptoms.—In pelvic fracture there is a history of violent force. There

are great shock, ecchymosis which is possibly linear, swelling, and intense pain increased by attempts at motion, coughing, and straining. There is also inability to sit or to stand. Mobility becomes obvious on grasping an ilium in each hand and moving the hands. Crepitus may be noticed by this maneuver or by moving an ilium with one hand, a finger of the other hand being inserted in the rectum or vagina. In making movements for diagnostic purposes be very gentle, as rough manipulation may cause injury by sharp fragments. There may be doubt as to whether crepitus is to be referred to pelvic fracture or to fracture of the neck of the femur; in this case follow the rule of John Wood: "The surgeon grasps the femur with one hand and places the other firmly upon the anterior superior iliac spine or crest or upon the pubes; then, on moving the femur and abducting it freely, if a crepitus be detected, it will be felt the more distinctly by that hand which rests on or grasps the fractured bone."

Rupture of the bladder is made manifest by pain in the hypogastric region, an intense desire to micturate, an inability to pass urine in quantity although a few drops of bloody urine may be voided, great shock, sometimes dulness on percussion in the loins, and evidences of extravasation in the prevesical space. The condition is proved to exist by practising the maneuvers suggested under Rupture of Bladder. The symptoms of ruptured urethra are set forth later. Bleeding from vagina or rectum points to laceration of the part by a fragment. The vagina may be badly lacerated and the bowels may emerge from the laceration (Maurice H. Richardson's case). Intestinal injury is apt to induce septic peritonitis. Fracture of the brim of the acetabulum permits dorsal dislocation of the femur to occur, which dislocation will not remain reduced, and causes shortening, which at once recurs when extension is abandoned—inversion and adduction, although the power of eversion and abduction is preserved (Stokes). There is crepitus, and the head of the bone goes with the fragment upward and backward (Stokes). If the head of the femur be driven through the acetabulum into the pelvis, the injury is very grave; there are then found shortening, adduction, and semiflexion of the thigh, absence of the prominence of the great trochanter, and more capacity for movement than is noted in dislocation. Fracture of the ischium rarely occurs alone.

Treatment.—Examine carefully to determine if the bowel, the bladder, the urethra, or the vagina is injured. If such an injury exists, radical operation is of course demanded. Always use a catheter to see if the urine is bloody. Bloody urine suggests, but does not prove, the existence of a ruptured bladder. It may be due to simple contusion of the bladder or to contusion of the kidney. In treating a pelvic fracture endeavor to restore the parts to a normal position, employing external manipulation and inserting a finger in the rectum or in the vagina. If reduction is difficult, administer ether. The pelvis should be encircled with a canvas binder and the patient should be placed upon a Bradford frame. If this is done he can be cleaned readily and the bed-pan can be easily used. If movements of the thighs distort the pelvic bones, each thigh should be bound to the frame. In fracture with separation of the pubic bones, the bones should be wired together. If urinary extravasation occurs, perform perineal section. If there are signs of bowel injury or intraperitoneal rupture of the bladder, perform laparotomy; and if the bladder is found to

be torn, apply sutures. All visceral injuries are treated by general rules. Remove the dressings in six weeks and allow the patient to get about in twelve weeks. In fracture of the acetabulum, if the limb is shortened, give ether and reduce by extension and counterextension. Treat these fractures in the same way as intracapsular fractures of the femur. Fractures of the ischium are best treated by the application of a pad and adhesive plaster, and rest in bed.

Fractures of the Sacrum.—This bone may be broken by direct force, such as a kick, but the injury is rare. The sacral plexus is usually injured, and if it is paralysis is observed in the territory of its branches.

Symptoms.—The symptoms of fracture of the sacrum are pain, frequently incontinence of feces and retention of urine, irregularity of the sacral spines, ecchymosis, and crepitus. Crepitus may be sought for with one hand externally and a finger of the other hand in the rectum. The lower fragment passes forward and may obstruct or may tear the rectum. Paralysis may be found in the area of distribution of the sacral plexus.

Treatment.—In any case of fracture of the sacrum if there are evidences of pressure upon nerves by displaced bone, incise and elevate the depressed bone. If the rectum is lacerated sutures must be inserted. In many cases of fracture of the sacrum the older conservative treatment is sufficient. The conservative treatment is as follows: Press the fragments into place with a hand externally and a finger in the rectum. Do not plug the rectum. Put a pad over the upper fragment, hold it with plaster or a binder, place the patient recumbent on a fracture-bed, and insert a large cushion underneath the pad. Some surgeons give opium to induce constipation, and allow a fecal support to accumulate in the rectum. Use a clean catheter regularly, and guard against bed-sores. Union occurs in about four weeks, when the dressing can be removed. The patient can get about again in six weeks. If urinary retention persists or if intractable bed-sores form after eight or ten weeks, cut down on the seat of injury and elevate or remove the portion of bone causing pressure.

Fractures of the Coccyx.—The coccyx may be broken or be separated from the sacrum by a fall, a blow, a kick, or the straining of parturition. Its mobility is so great, however, that it does not often break.

Symptoms.—The chief symptom of fracture of the coccyx is pain, which is much aggravated by sitting, walking, or straining at stool. If the index finger is inserted into the rectum, the displaced bone is felt; if the thumb of the same hand is also placed externally, a rocking motion will develop crepitus and preternatural mobility.

Treatment.—In treating fracture of the coccyx reduce by external pressure and by the manipulations of a finger in the rectum and put the patient to bed. In four weeks the fracture should be united. If union does not take place, defecation and all movements of the coccyx will cause excruciating pain by pressure on the last sacral nerve. This condition, known as "coccygodynia," demands a subcutaneous division of the nerve or of the muscles which move the coccyx, or a resection of the bone.

Fractures of the Vertebra. (See page 756.)

Fractures of the Skull. (See page 706.)

Fractures of the Clavicle.—The clavicle is more often fractured than any other bone. The fracture may occur at any age, but is commonest

before the sixth year (Hulke says one-half of the recorded cases). It may be simple, multiple, comminuted, oblique, transverse, complete, incomplete, or, very rarely, compound. Both clavicles may be broken. Fractures are most apt to occur just external to the middle, at the point where the inner or large curve meets the outer or small curve, at which junction the bone is at its smallest diameter. Fractures of the acromial end are more frequent than fractures of the sternal end, and less frequent than fractures of the shaft. The *causes* of fracture of the clavicle are direct violence, indirect violence, and, very rarely, the contractions of "the deltoid and clavicular fibers of the great pectoral" (Treves, from Polaillon).

Fractures of the shaft are usually due to indirect violence, as falls upon the shoulder or upon the outstretched hand. In the latter accident, which is the usual mode of origin, the concussion of the fall travels up and the body-weight travels down, and these two forces compress the bone, which snaps at its weakest point. Fractures from indirect force are oblique, and in children are of the green-stick form. Fractures from direct force are usually transverse, and are occasionally comminuted. Fractures from muscular action have been recorded (Rubini the tenor, recorded by Melay).

Symptoms.—In fracture of the shaft of the clavicle the attitude of the patient is peculiar. He supports the elbow or wrist of the injured side with the hand of the sound side, and also pulls the extremity against the chest; the head is turned down toward the shoulder of the damaged side, as if trying to listen to something in the joint, thus relaxing the pull of the sternocleidomastoid muscle upon the inner fragment. The shoulder is nearer the sternum, on a lower level, and farther front than that of the sound side. Loss of function is shown by inability to abduct the arm, and in many cases by inability to place the hand on the top of the erect head. Considerable pain exists, which is increased by motion, by pressure, and by hanging down the extremity without support.

The deformity above noted is described by stating that the shoulder goes downward, inward, and forward (D. I. F.). The *downward* deformity is chiefly due to the weight of the extremity, which pulls down the unsupported outer fragment, and is contributed to by the action of the pectoralis minor muscle. The *inward* deformity is chiefly due to the contraction of the pectoralis minor and subclavius muscles assisted by the action of the pectoralis major. The *forward* deformity is due to rotation of the outer fragment, which is brought about by the serratus magnus muscle carrying the scapula forward. In this deformity, the inner end of the outer fragment is below and behind the outer end of the inner fragment, which overrides it. The inner fragment, though pulled on by the sternocleidomastoid muscle and relatively higher than the outer fragment, is really but little, if at all, elevated, marked elevation being prevented by the attachment of the rhomboid ligament. After noting the deformity, detect with the finger the irregularity of bony contour. Examine for preternatural mobility and crepitus by raising and throwing back the shoulder. In looking for these signs in children it is to be remembered that the fracture is probably incomplete. The prognosis is good, the bone uniting, but always with some shortening and inequality.

Complications.—Fractures of the shaft are rarely compound, because the sharp end of the outer fragment passes backward and because of the free

play the skin makes over the bone (Pickering Pick). Both clavicles may be broken. One or more ribs may be fractured at the same time. In fractures from direct force deeper structures may be injured by fragments. Thus, injury of the brachial plexus will induce paralysis. There are 11 recorded cases of simple fracture of the clavicle complicated by laceration of a large vessel. Eight of these cases died. The vessel ruptured may be the subclavian vein, the subclavian artery, or the jugular vein. After a rupture a huge blood-clot forms (Gallois and Piollet, in "Rev. de Chir.," July and Aug., 1901).

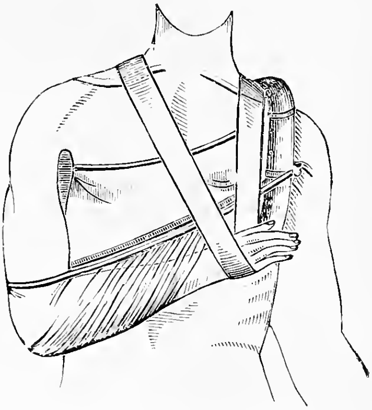


Fig. 224.—Fox's apparatus for fractured clavicle.

Treatment.—In treating a fracture of the shaft of the clavicle correct the deformity as soon as possible by throwing the shoulder upward, outward, and backward. If the patient is a girl, it is desirable to minimize the deformity. Place her upon her back upon a hard bed, with a small pillow under her head, a firm and narrow cushion between the shoulders, a bag of shot resting over the seat of fracture, and the forearm lying on the front of the chest, the arm being held to the side by a sandbag. In three weeks there will be union, practically without deformity. In a child with an incomplete fracture a handkerchief sling for the forearm, worn three weeks, is all that is needed. In a fracture of the collarbone of an adult the Velpeau bandage is efficient. Before applying it, place lint around the chest and cotton over the elbow. Change the bandage every day for the first week, and after that period every third day. Each time it is changed rub the skin with alcohol, ethereal soap, or soap liniment, dry carefully, and examine for excoriations; if any are found, they are anointed with zinc ointment before the dressing is reapplied. The dressing is permanently removed at the end of four weeks, the arm being carried in a sling for another week. The classical apparatus of Desault is now rarely used. The posterior figure-of-eight bandage associated with the second roller of Desault, some turns being made from the elbow of the injured side to the shoulder of the sound side, can be used in cases in which the forward deformity is apt to return. The apparatus of Fox, which is very useful, consists of a pad for the axilla, a sling for the forearm, and a ring for the opposite shoulder, to which ring are tied the tapes from both the pad and the sling (Fig. 224).

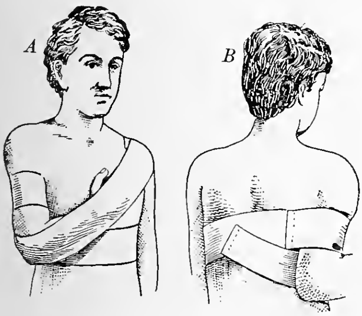


Fig. 225.—Sayre's adhesive-plaster dressing for fracture of the clavicle (Stimson): *A*, First piece; *B*, second piece.

The dressing of Moore, of Rochester, is valuable in an emergency. It consists of a piece of cotton cloth, two yards long, and folded like a cravat until it is eight inches in width at the middle. The center of the bandage rests upon the elbow, the posterior tail is carried across the front of the shoulder of the injured side. The forearm is at an acute angle with the arm, and the other end of the bandage is carried across the forearm, across the back over the opposite shoulder, and around the axilla, where the extremities are stitched together. The forearm is suspended in a bandage sling (S. D. Gross). The four-tailed bandage is preferred by Pick. Sayre's dressing has many advocates (Fig. 225). For this there are required two pieces of rubber plaster, each piece being three inches wide and sufficiently long to go around the chest one and a half times. The end of one piece encircles the arm of the injured side just below the arm-pit; the plaster strip is pulled across the back to the other side, to the front of the chest, and returns again to the middle of the back. This procedure pulls the elbow back and throws the shoulder out. The hand of the injured side is placed on the breast of the opposite side, cotton being interposed, and the second strip of plaster runs from the elbow of the injured side and the opposite shoulder, front, around, and back, pressing the elbow forward, upward, and inward. In children, if it is found difficult to immobilize the parts, the most satisfactory result is obtained by the application of the Velpeau bandage, which is to be overlaid by a thin plaster-of-Paris bandage. If the fragments cannot be coaptated, sterilize the parts, administer ether, incise, clear away the muscle from between the fragments, saw the ends, bore each end and hold them in contact by means of kangaroo-tendon or silver wire. The same procedure should be pursued when a fracture is compound or threatens to become so, or if signs indicate pressure upon vessels or nerves. If a large vessel has been injured, the operation is imperatively necessary. If a patient suffering under a fracture which threatens to become compound refuses the aid of operation, keep him in bed and hold the arm in abduction. In three cases in the Jefferson Medical College Hospital the author wired the fragments with excellent results.

After a broken collar-bone has united, if the shoulder is found to be stiff, make passive movements daily; if these fail, move the joint forcibly, first giving ether or nitrous oxid.

Fractures of the acromial end of the clavicle are due to direct force. If the fracture is between the two coracoclavicular ligaments, deformity is very slight, crepitus is elicited by manipulating with the fingers, and pain exists, but loss of function is not markedly manifest unless it is due to pain. These fractures are treated by interposing cotton between the arm and the side, binding the arm to the side with the second roller of Desault, and hanging the hand in a sling. In fractures external to the ligaments crepitus is manifest on moving the shoulder, the outline of the bone is irregular, severe pain is developed by movement, and deformity is pronounced. The deformity is due to the serratus magnus muscle rotating the scapula forward, the inner end of the outer fragment of the clavicle often coming in contact with the anterior surface of the outer portion of the inner fragment. Fracture of the acromial end of the clavicle is reduced by pulling both of the shoulders strongly backward, and it is kept reduced by the use of a posterior figure-of-eight bandage. In fracture

external to the ligaments the displacement frequently cannot be corrected by position and manipulation. Such cases demand incision and wiring. In either variety of fracture the dressings are worn for four weeks.

Fractures of the sternal end of the clavicle are very rare. They are caused by either direct or indirect force. In such a fracture there are found crepitus, projection at the seat of fracture, rigidity of the sternocleidomastoid muscle, and shortening of the clavicle. The inner end of the outer fragment always passes forward, and often also downward and inward. Reduce these fractures by pulling the shoulders back, and treat them by means of the posterior figure-of-eight bandage worn for four weeks. Wiring may be necessary.

Fractures of the Scapula.—This bone is not often broken, as it rests upon thick muscles and elastic ribs; it is freely movable, and it has attached to it a bone which easily breaks.

Fractures of the Body of the Scapula.—These are due to direct violence. The *symptoms* are pain (which becomes agonizing on attempting to rotate the shoulder-blade), ecchymosis, and swelling. Crepitus is sought for by placing the hand over the bone and making movements of the arm; also by holding the point of the shoulder and lifting up the lower angle of the bone. The latter plan may develop mobility. The spine of the scapula is uneven only when it is itself fractured. Examine for unevenness of the vertebral border of the shoulder-blade. In fractures of the body of the scapula a shoulder-cap is applied, a gutta-percha splint is moulded over the scapula, the arm is bound to the side, and the hand is carried in a sling. The apparatus is worn for four weeks.

Fractures of the spine of the scapula are treated as are fractures of the body of the bone, and for the same time.

Fractures of the Neck of the Scapula.—Fracture of the *anatomical neck* has not been proved to exist. Fracture of the *surgical neck* is evinced by flattening of the shoulder, prominence of the acromion, and the presence of a lump in the axilla, crepitus being developed by pressing the axillary prominence upward and backward. The coracoid process descends with the humerus. The deformity is reduced with ease, but it at once recurs. The condition is treated by placing a pad in the axilla, a shoulder-cap on the shoulder, applying the second roller of Desault, and supporting the forearm and elbow in a sling. A Velpeau dressing can be used, associated with the application of a folded towel in the axilla. The dressing is to be worn for five weeks.

Fractures of the glenoid cavity are not very unusual, and may occur with or without dislocation. Fracture of this region arises from direct force applied to the shoulder. The existence of this fracture is determined by excluding fractures of other bones and by detecting crepitus when the arm is at a right angle to the body and the humerus is pushed against the glenoid cavity, the crepitus not being found when the arm hangs by the side.

Treatment is by the second roller of Desault and a forearm sling worn for four weeks; careful passive movements limit ankylosis. If ankylosis occurs, adhesions must be broken up while the patient is under ether or nitrous oxid.

Fractures of the acromion process are often met with as the result of direct violence. The existence of fracture of the acromion is indicated by pain, by inability to abduct the arm, by flattening of the shoulder, by

sudden lowering of the point of the shoulder, by mobility, and by crepitus. To treat a case of this kind, put a large pad in the axilla with the base down, bind the arm over the pad with the second roller of Desault, lifting the elbow with turns of the roller carried over it and the opposite shoulder, thus splinting the bone in place by the head of the humerus pushing against the coraco-acromial ligaments. The dressing is to be worn for four weeks.

Fractures of the coracoid process rarely happen alone, and may arise from direct force or from muscular action. But little displacement is found. Crepitus and mobility are usually detected. Inability to shrug the shoulder inward was pointed out as a symptom by Byers. Such a case is well treated by a Velpeau bandage, which is to be worn for four weeks.

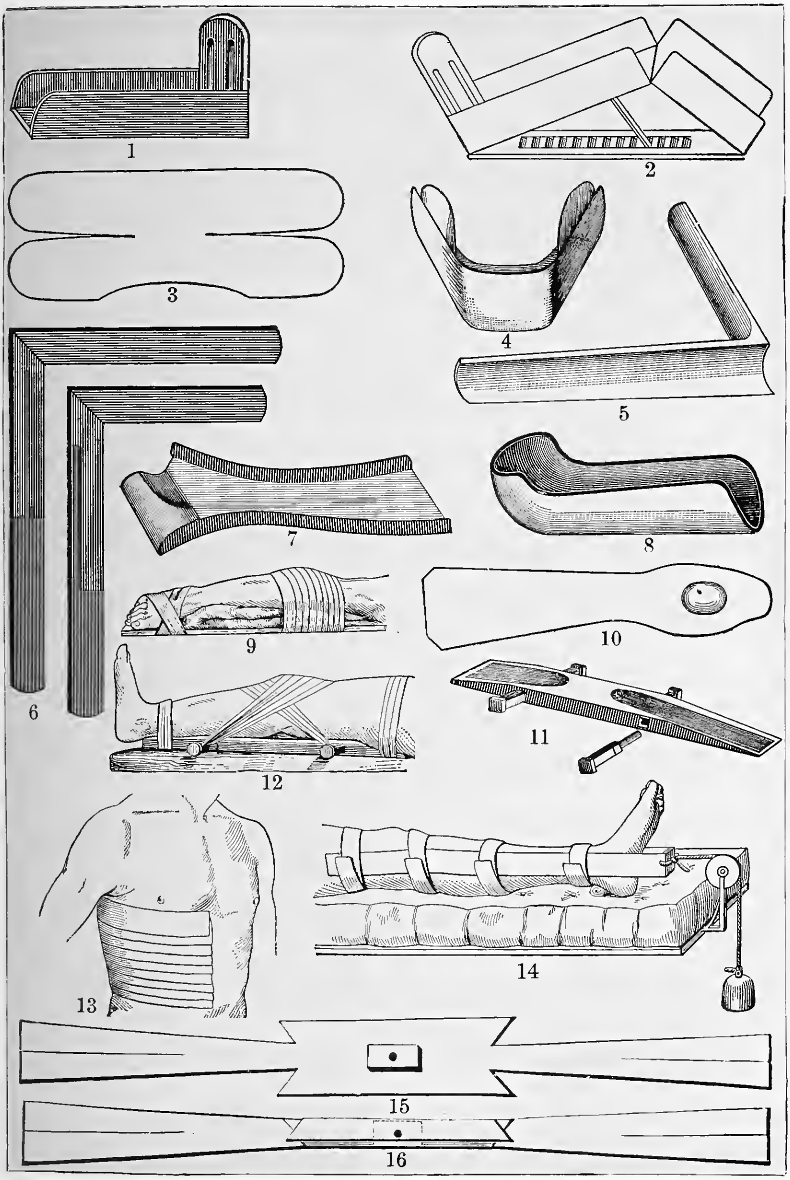
Fractures of the humerus are divided into (1) fractures of the upper extremity; (2) fractures of the shaft; and (3) fractures of the lower extremity. In examining any fracture of the humerus, feel at once for the pulse, so as to ascertain if the artery has been torn; in any fracture near the head of the humerus be certain that dislocation does not exist.

Examination of the Shoulder.—In some cases ether must be administered. Compare the injured shoulder with the sound shoulder, the patient, if not anesthetized, being seated in a chair or stool. The direction of the axis of the arm is noted. The surgeon grasps the flexed elbow with one hand and the shoulder with the other; he thus can move the extremity and palpate the joint and adjacent points. The shoulder is moved gently in every direction, and the surgeon notes if the head of the bone moves with the shaft. Examination shows if the head of the bone is in place or if the glenoid cavity is vacant—if the head of the bone is in an abnormal situation, if it is altered in contour, if there is crepitus or preternatural mobility, and if any movement is impaired. The acromion process, outer end of the clavicle, coracoid process of the scapula, and neck of the scapula are also investigated. The length of the arm is obtained by measuring from the apex of the acromion process of the scapula to the apex of the external condyle of the humerus, and it is compared with the length of the sound extremity.

1. **Fractures of the upper extremity of the humerus** include (*a*) fractures of the anatomical neck; (*b*) fractures of the surgical neck; (*c*) fractures of the head, oblique and longitudinal; and (*d*) separation of the upper epiphysis.

Fractures of the Anatomical Neck of the Humerus.—The anatomical neck is the constricted circumference of the articular surface, and fractures of it, though rare, do occur, especially in the aged. The line of fracture in some cases follows the insertion of the capsule, in others it is entirely within the capsule, but in most it is without the capsule above and within the capsule below; hence the term "intracapsular" is rarely correct as a designation. Such a fracture may be impacted. The *cause* is direct violence or a fall or a blow upon the elbow when the arm is abducted. Polloson, of Lyons,* has reported a case due to muscular action. The patient died in eclampsia, and at the necropsy it was found that both humeral heads were fractured and impacted. The fractures must have been produced by the muscles throwing the heads of the bones violently against the glenoid cavities, probably by adduction.

* Rev. de Chir., vol. viii, 1888.



1. Fracture-box. 2. Double Inclined Plane Fracture-box. 3. Jaw-cup (unfolded). 4. Jaw-cup (folded). 5. Anterior Angular Splint. 6. Internal Angular Splint. 7. Bond Splint. 8. Shoulder-cap. 9. Dupuytren Splint in Pott's Fracture. 10. Agnew Splint for Fracture of the Metacarpus. 11. Agnew Splint for Fracture of the Patella. 12. Agnew Splint applied. 13. Strapping the Chest in Fractured Ribs. 14. Extension Apparatus in Fracture of the Femur. 15, 16. Adhesive Strips for Extension Apparatus.

Symptoms.—The symptoms in fracture of the anatomical neck are pain, swelling, ecchymosis, slight irregularity of the shoulder (which irregularity is soon hidden by tumefaction), and inability to actively abduct the arm. Deformity, as a rule, is slight or is absent, because the capsule is rarely entirely torn from the lower fragment. If deformity exists, it is due to the muscles inserted on the bicipital groove and to the coracobrachialis, which pull the lower fragment inward and forward. Treves says that a tear of the reflected fibers of the capsule leads to subsequent necrosis, because this joint has no ligamentum teres. In unimpacted cases there is crepitus, and mobility of the shaft can be detected near the head of the bone. In some cases impaction occurs, the upper fragment impacting into the lower. In this condition there are very slight shortening and trivial shoulder-flattening,

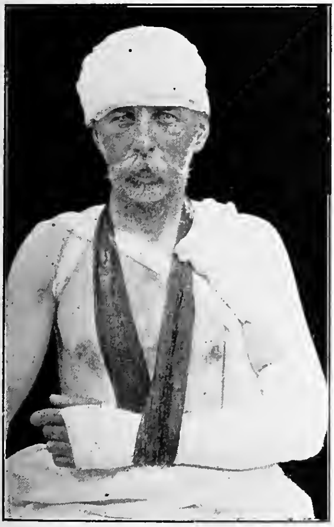


Fig. 226.—Fracture at upper end of the humerus. Note hand, forearm, and elbow bandaged; axillary pad and strap, plaster-of-Paris shoulder-cap, sling (Scudder).

Fig. 227.—Fracture at upper end of the humerus. Arm and elbow bandaged. Axillary pad and shoulder-cap in position. Application of circular bandage to trunk and shoulder. Sling not shown (Scudder).

no crepitus unless the tuberosity is broken off, no mobility, and, as Erichsen says, the head of the bone, while it can be felt through the axilla, is not in the axis of the limb.

The *prognosis* of fracture of the anatomical neck is usually good for bony union (Hamilton, Pick, and R. W. Smith), but a stiff joint is apt to result.

Treatment.—Feel the pulse to be sure the artery is untorn. In most cases an anesthetic should be given in order to examine with ease and dress with satisfaction. Sometimes the fragments are readily coaptated; occasionally they are not. In a case reported by Carl Beck the axes of the fragments were at right angles and they could only be kept in contact by holding the arm at a right angle to the body ("New York Med. Jour.," April 5, 1902). Some surgeons treat this fracture by simply hanging the wrist in a sling

and suspending a bag of shot from the elbow to make extension. The usual plan of treatment is as follows: flex the arm to a right angle with the body, and carry up from the base of the fingers to above the elbow the turns of a spiral reversed bandage made of flannel. Interpose lint between the arm and the side, and place a V-shaped pad with the apex upward in the axilla. tying the tapes over the opposite shoulder. A shoulder-cap made of pasteboard (Pl. 6, Fig. 8) or plaster-of-Paris (Fig. 226), moulded to fit and well lined with cotton, is applied. The plaster-of-Paris cap is the most satisfactory. It is applied "so as to cover the whole shoulder, the anterior and posterior aspects of the chest and the outer side of the upper arm down to the external condyle of the humerus" (Scudder, on "The Treatment of Fractures") (Fig. 226). The arm with the shoulder-cap is fixed to the side by the second roller of Desault, and the wrist is hung in a sling (Fig. 227). The edges of the bandage should be stitched together. This apparatus is changed daily for the first few days, the body and arm being rubbed at each change with alcohol, soap liniment or ethereal soap. After this period a change every third or fourth day is often enough. Massage is begun at the end of one week, but rotation and motion of the joint are not employed until after three weeks. The dressings are removed at the end of four weeks, the forearm being carried in a sling for two weeks more. In impacted fracture do not pull apart the impaction, do not use a pad, but apply a cap to the shoulder and fix the arm to the side for five weeks. The fracture unites with deformity.

Fractures of the Surgical Neck of the Humerus.—The surgical neck is the constricted portion of bone between the tuberosities and the upper line of the insertion of the muscles on the bicipital groove. Fractures in this region are usually transverse, but they may be oblique. The *causes* are: direct force almost always; indirect force occasionally; and muscular action in rare instances.

Fig. 228.—Internal angular splint and shoulder-cap in fracture of the surgical neck of the humerus.

Symptoms.—The symptoms in fracture of the surgical neck are: pain running into the fingers from pressure upon the brachial plexus; crepitus and mobility on extension; and flattening, which differs from the flattening of dislocation in that it occurs farther below the acromion and that this process is not so prominent. Shortening to the extent of an inch is noted. The head of the bone can be felt in the glenoid cavity, but it does not move on rotating the arm. The upper end of the lower fragment is felt and moves on rotating the arm. The displacement is pronounced. The lower fragment is pulled upward by the deltoid, biceps, coracobrachialis, and triceps; inward by the muscles of the bicipital groove; and forward by the great pectoral; thus, the upper end of the lower fragment projects into the axilla, and the elbow lies from the side and backward. Péan holds that the violence drives the lower fragment forward. The upper fragment is abducted and rotated outward, which position is due, it is generally taught, to the action of the supraspinatus, infraspinatus, and teres minor muscles. In some cases displacement is for-

ward, and in other cases it is not obvious. The lower fragment may impact into the upper, in which case the symptoms are obscure and the diagnosis is made by exclusion. If the impaction is solid and complete, there are the history of direct force, the impaired movements, the slight deformity, and the absence of crepitus. In all fractures of the upper end of the humerus the distinction can be made from dislocation by feeling the head of the bone under the acromion and by noting that it does not move on rotating the arm.

The *prognosis* of fracture of the surgical neck of the bone is good.

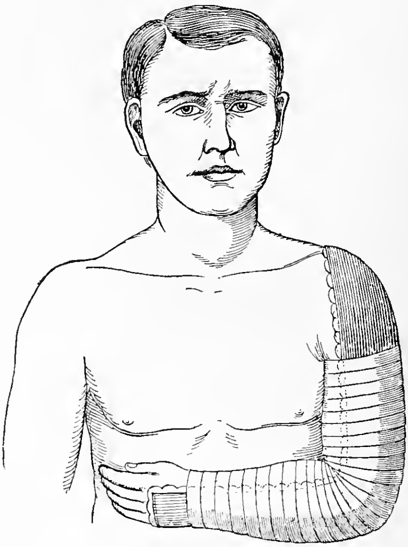


Fig. 229.—Apparatus for fracture of the humerus at any point above the condyles.

Treatment.—Some surgeons treat a fracture of the surgical neck in exactly the same manner as a fracture of the anatomical neck. We prefer the following plan: In many cases give ether in order to examine and dress. Feel the pulse to see that the artery has not been damaged. Reduce by traction and manipulation; if there is an impaction, pull it apart. Take an internal angular splint (Pl. 6, Fig. 6) and pad it well, putting on extra padding at the points that are to rest against the palm, the inner condyle, and the axillary folds. Lay the arm and pronated forearm upon the splint. Apply a padded shoulder-cap. Fix the splint and cap in place with a spiral reversed bandage terminating as a spica of the shoulder, and hang the hand or forearm in a sling (Fig. 228). The dressing is to be worn for four weeks, and the rules to be followed in changing it are the same as in fracture of the anatomical neck. Massage is used after one week and passive motion after four weeks to amend stiffness. In rare cases—those with strong anterior projection of the lower end of the upper fragment—apply an anterior angular splint. In some cases where the deformity strongly tends to recur support by a plaster-of-Paris trough on the back and sides of the arm and shoulder (Fig. 229), or maintain extension by weights and pulleys, the patient being kept in bed (Stimson).

Longitudinal and Oblique Fractures of the Head of the Humerus.—By this term may be designated separation of the great tuberosity, or separation of a portion of the articular surface, together with the great tuberosity, from the shaft and lesser tuberosity (Pickering Pick, Guthrie, and Ogston). The *cause* is direct violence to the front of the shoulder.

Symptoms.—The symptoms in longitudinal and oblique fracture of the head are broadening and flattening of the shoulder with projection of the acromion. The upper fragment passes upward and outward, and the lower fragment passes upward and inward to rest on the margin of the glenoid cavity below the coracoid process. The elbow is drawn from the side, there

is some shortening, and the patient cannot abduct his arm. If the surgeon grasps the patient's elbow and holds it to the side and rotates the arm while with his other hand he grasps the upper fragment, crepitus is very positive. Examination develops wide separation of the fragments. The deformity cannot be entirely corrected, because the biceps tendon usually gets between the fragments (Ogston), but a useful limb can usually be obtained.

Treatment.—The plan which gives the best result in treating longitudinal and oblique fracture of the head of the bone is to place the patient on his back upon a hard bed with a small, firm pillow under his head, abduct the arm above the head, rotate it outward so that the back of the hand rests on the bed, and hold it in place by sand-bags. This position should be maintained for three weeks, at the end of which period the fracture can be treated for three weeks more as is a fracture of the anatomical neck. If the patient refuses to go to bed, treat the injury as a fracture of the anatomical neck, padding well over the tuberosities. The dressings should be worn for five weeks, passive motion being made after four weeks. In the above injury feel at once for the pulse, to see if the artery has been torn.

Separation of the Upper Epiphysis of the Humerus.—The epiphysis is united during the twentieth year. Separation is a rare accident and is produced by direct force.

Symptoms.—The chief symptom in separation of the upper epiphysis is projection of the upper end of the lower fragment inward, forward, and upward beneath the coracoid, and consequently a projection of the elbow backward and from the side. If the lower fragment passes forward and not inward, the elbow simply passes back. The upper end of the lower fragment is smooth and convex. Rotation of the shaft develops soft crepitus when the fragments are in contact.

The *prognosis* is good for bony union, though the future growth of the limb may be impaired.

Treatment.—The treatment for separation of the upper epiphysis is a pad in the axilla, a shoulder-cap, binding the arm to the side, and hanging the hand in a sling. Wear the dressing for four weeks, and begin passive motion as directed when dealing with fracture of the upper end of the humerus.

2. **Fractures of the Shaft of the Humerus.**—Fracture of the shaft of the humerus is a very common accident. The *cause* is usually direct violence, such as a blow. The fracture may arise from indirect violence, such as a fall upon the elbow. Muscular action is not rarely also a cause, as in throwing a ball, in catching a tree-limb while falling, or in turning another's wrist as a test of strength (Treves).

The *symptoms* of fracture of the shaft of the humerus are pain, swelling, ecchymosis, inability to move the arm, mobility, and distinct crepitus. Shortening to the extent of three-fourths of an inch occurs. The displacement varies with the situation of the fracture and the direction of the force. If the fracture is above the insertion of the deltoid, the lower fragment is pulled up by the triceps, biceps, and deltoid, and pulled out by the deltoid, and the upper fragment is pulled inward by the arm-pit muscle. In fracture below the deltoid this muscle is apt to pull the lower end of the upper fragment outward, while the lower fragment passes inward and upward because of the action of the biceps and triceps. Injury of the *musculospiral nerve*

sometimes occurs. The nerve may be contused, producing pain at the seat of bruising, and tingling and numbness in the region supplied by the nerve.

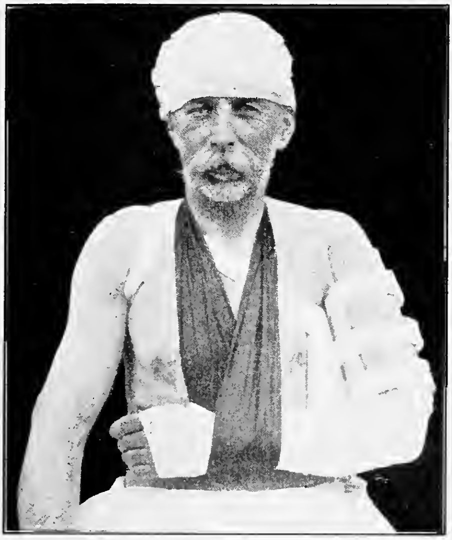


Fig. 230.—Fracture of the shaft of the humerus. Note bandage to hand, forearm, and elbow; axillary pad and strap; coaptation splints and sling. Bandage does not cover fracture (Scudder).

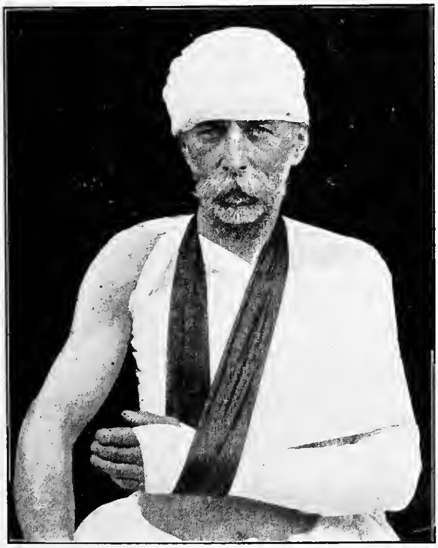


Fig. 231.—Fracture of the shaft of the humerus. Note bandage to hand, forearm, and elbow; adhesive-plaster swathe holding arm upon axillary pad and covering coaptation splints. Sling (Scudder).

In most cases the symptoms soon pass away, but sometimes neuritis ensues. A severe contusion produces not only pain, but paralysis of the muscles

supplied by the nerve, and surface anesthesia. In most cases this condition is recovered from in a few weeks, but sometimes it lasts a long while or even permanently. In musculospiral paralysis the patient is unable to extend the wrist and fingers or to supinate the forearm. There is "complete loss or impaired sensation in the lower half of the outer and anterior aspect of the arm and in the middle of the back of the forearm as far as the wrist" (Scudder, in "The Treatment of Fractures"). The nerve may be divided by a sharp fragment, paralysis of motion and anesthesia resulting at once. In some cases the nerve is caught in and compressed by callus, scar-tissue, or fragments, motor and sensory disturbances resulting.

The *prognosis* is good, but the fact should always be remembered that ununited fractures are commoner in the humerus than in any other bone. Treves believes this to be due to entanglement of muscle between the fragments, lack of fixation of the shoulder-joint, and imperfect elbow-support. Hamilton believes that it is due to the facts that the elbow soon becomes fixed at a right angle, and that any movement of the forearm moves the seat of fracture, and not the elbow.

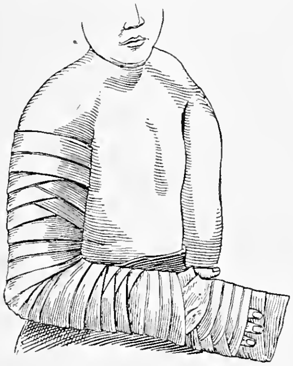


Fig. 232.—Internal angular splint in fracture of the shaft of the humerus.

Treatment.—It is rarely necessary to anesthetize unless the patient be a nervous woman or an excitable child. Feel the pulse, to be certain the artery has not been lacerated. Reduce the fracture by extension, counter-extension, and manipulation. Apply an internal angular splint without the shoulder-cap (Fig. 232). If this splint does not maintain coaptation of the fragments, associate with it three short humeral splints instead of the shoulder-cap used in fractures near the shoulder-joint. Splints are to be worn for five or six weeks, and after the removal of the splints the wrist is hung in a sling. The sling is dispensed with eight weeks after the infliction of the injury. Passive movements are not to be made until the fracture is well united (after five or six weeks), for, if made too soon, they predispose to non-union, and, as no joint is involved, genuine ankylosis will not occur. Many surgeons treat these fractures by applying plaster-of-Paris to the forearm and the arm (the elbow being flexed to a right angle), binding the arm to the side and hanging the wrist in a sling. Others apply a trough to the arm and forearm (Fig. 229). Scudder prefers to bandage the hand, forearm, and elbow, and apply an axillary pad, coaptation splints, a swathe of adhesive plaster holding arm to the side, and a sling (Figs. 230, 231). In any case in which it is impossible to obtain and maintain correct apposition of the fragments, cut down upon them, and apply sutures. If the nerve is divided, an incision must be made, and the nerve sutured and the bone wired. If the nerve is caught in the callus, after repair has taken place the nerve must be liberated by chiseling the callus away. Neuritis is treated by blisters over the nerve, the use of the descending galvanic current, and the administration of salicylate of ammonium and the bromids.

3. **Fractures of the Lower Extremity of the Humerus.**—These fractures are spoken of as fractures in, or in the neighborhood of, the elbow-joint, and they include (*a*) fractures of the external condyle; (*b*) fractures of the internal condyle; (*c*) fractures of the internal epicondyle; (*d*) fractures at the base of the condyles; (*e*) T- or Y-shaped fractures; (*f*) epiphyseal separation; and (*g*) fractures of the capitellum and trochlea. There may be more than one fracture, or there may be also a dislocation of the humerus, of the ulna, or of both bones. Rarely the fracture is compound. These fractures are frequent injuries in childhood, and are not uncommon in adults.

Method of Examination.—A fracture of the elbow is rapidly followed by great swelling, and the diagnosis is often very difficult. In most cases, when possible, the *x*-rays should be used in arriving at a diagnosis. In every case in which the *x*-rays are not used, and in most cases in which they are, the surgeon examines the parts carefully while the patient is under ether. If swelling is very great, it is necessary to abate it in order to reach any conclusion as to the condition. We can bandage the arm, rest it semiflexed on a pillow, and apply evaporating lotions or even an ice-bag for a day or two, or, what is better, temporarily diminish the swelling by Gerster's plan, which is as follows: Apply an Esmarch bandage from the hand to well above the seat of fracture; this will drive away extra-articular swelling and permit of thorough examination. It is a great advantage to have the patient anesthetized, for then not only can we make an accurate diagnosis, but we can reduce the fracture satisfactorily and apply a careful first dressing.

Compare the injured with the sound elbow. Note swelling and local ecchymosis. Feel the radial pulse. Note the "carrying angle" (Fig. 234). Measure each arm from the tip of the acromion process of the scapula to the tip of the external condyle of the humerus. Feel each prominent body-point and note if it is mobile (condyles, olecranon, head of ulna). Feel the shaft just above the condyles. Mark with ink on each elbow the tip of the external condyle, the tip of the internal condyle, and the tip of the olecranon, and observe the relation between these points of each elbow in flexion and in extension. In an uninjured elbow a straight line transverse to the long axis of the limb with the joint in extension will pass through the condyles and leave the tip of the olecranon just a shade above it. "When the elbow is at a right angle, these three points will be found in the same plane with the back of the upper arm" (Scudder, in "The Treatment of Fractures"). Rotate the radius while a thumb is held against the head of the bone. Make flexion and extension of the elbow and determine if there is any lateral motion. Test for mobility just above the condyles. The above maneuvers will determine the presence or absence of crepitus, preternatural mobility, deformity, etc.

Fractures of the External Condyle of the Humerus.—A fracture of the external condyle runs into the joint and the capitellum is usually broken off. Such an injury occurs oftenest in children, being due to falling on the hand; but it may occur from direct force, and may happen to adults.

Symptoms.—The symptoms of fracture of the external condyle are severe pain, great swelling, and crepitus (found on pressing or moving the condyle and on rotating the radius). Mobility may also be discovered. A projection

is felt on the outer and posterior surface of the elbow. The forearm is semi-flexed and supinated. The patient cannot use the joint.

Fractures of the Inner Epicondyle of the Humerus.—The inner epicondyle is an epiphysis which unites during the seventeenth year. It not infrequently breaks from muscular action or from direct violence, and the fracture does not involve the joint. Crepitus and mobility can be detected. Displacement is slight. The *outer epicondyle* is never fractured alone.

Fractures of the Internal Condyle of the Humerus.—The line of fracture after a break of the internal condyle runs into the joint, to the trochlear surface of the humerus. The *cause* is always direct violence.

Symptoms.—In fracture of the internal condyle the fragment, accompanied by the ulna, goes upward and backward, and when the forearm is extended

Fig. 233.—Loss of carrying function after fracture of inner condyle of the humerus.

the ulna projects posteriorly, the lower end of the humerus being felt in front. The fragment forms a projection back of the elbow. Crepitus and preternatural mobility can be found if swelling is not too great. Crepitus is detected by flexing and extending the forearm. The space between the condyles is broader than normal, and the forearm takes a bend toward the ulnar side, the "carrying function" of the forearm being lost (Fig. 233). When a person carries a heavy object, such as a bucket, he instinctively rests the inner condyle upon the pelvis, and the normal deviation of the forearm outward keeps the bucket from striking the leg. This deviation outward when the inner condyle rests against the ilium gives us the carrying function. In fracture of the inner condyle the broken condyle ascends and the "carrying function" is lost (Fig. 234).

Fractures at the Base of the Condyles of the Humerus.—A fracture in this region is just above the olecranon and is on a higher level behind than in front. The *cause* is direct force acting upon the olecranon.

The *symptoms* are loss of function and pain from injury of the median or ulnar nerve. Crepitus and mobility are readily found. The lower fragment is drawn backward and upward by the action of the triceps, biceps, and brachialis anticus muscles. The lower end of the upper fragment projects in front of the joint. This lesion may be mistaken for dislocation of the bones of the forearm backward. In fracture the limb is mobile; in dislocation it is rigid. In fracture the deformity is easily reduced and strongly tends to recur; in

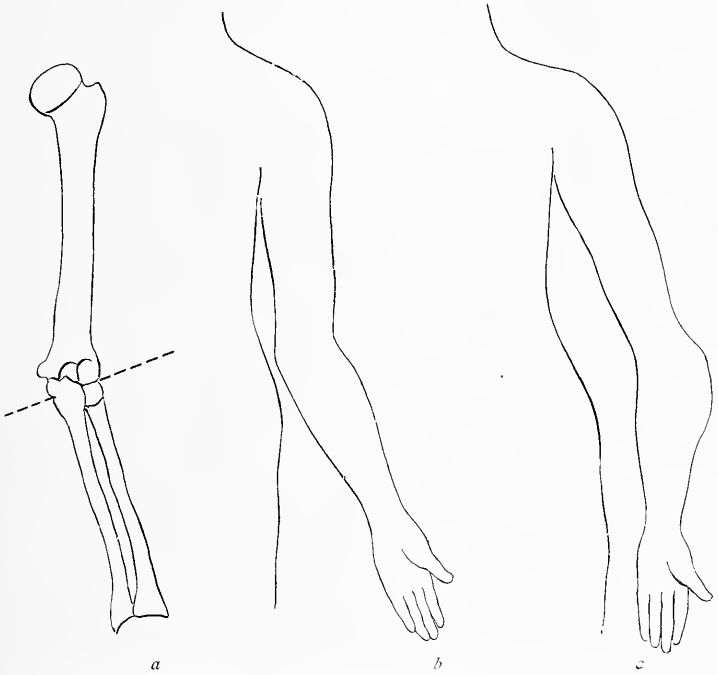


Fig. 234.—Diagram to exhibit the "carrying function" of the forearm, and the loss of this function in fracture of the inner condyle of the humerus: *a* and *b* show the normal relation of the parts when carrying; *c* shows the alteration of axis of the forearm when the inner condyle is fractured, what is known as gunstock deformity resulting (after Allis).

dislocation the deformity is reduced with difficulty and does not tend to recur. In dislocation there is shortening of the forearm, but not of the arm; in fracture there is shortening of the arm but not of the forearm. In dislocation there is a smooth, large projection below the crease in front of the elbow; in fracture there is a sharp projection above the crease. In fracture there is crepitus; in dislocation there is no crepitus.

The *diagnosis* can usually be settled by the Röntgen rays.

T-fractures of the Humerus.—A T-fracture consists of a transverse fracture above the condyles plus a vertical fracture between them. The *cause* is violent direct force applied posteriorly.

Symptoms.—The symptoms are increase in breadth of the joint (Fig. 235) preternatural mobility, crepitus, pain and swelling, mounting up of the inner condyle back of the elbow on the inner side, and of the outer condyle back of the elbow on the outer side. The forearm is semiflexed and supinated, and the carrying function is lost.

Prognosis of Fractures in or near the Elbow-joint.—In many fractures it is difficult or impossible to obtain reduction, and in some it is impossible to maintain reduction. Stimson is undoubtedly right when he says that "in intercondyloid fracture with marked separation there is no practicable means merely to maintain reduction."* The prognosis for complete restoration of function is bad, and in most of these fractures some deformity and considerable stiffness are inevitable. Ankylosis partial or complete is a not unusual sequence. Ankylosis may result from prolonged immobilization, the muscles contracting and becoming fibrous, the fascia and ligaments about the joint shortening, the capsule shrinking and thickening, some of the cartilages becoming

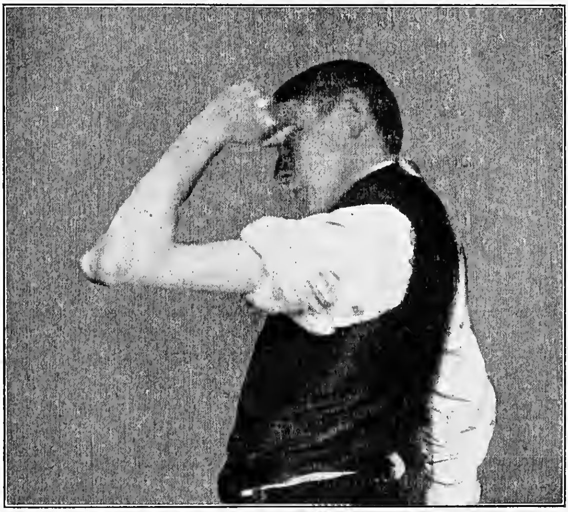


Fig. 235.—Deformity following fracture of the humerus between the condyles.

fibrous, and the joint being partly obliterated. It may result from extravasation of blood into the joint and tendon-sheaths with subsequent formation of fibrous tissue. It may arise from organization of inflammatory exudate within and about the joint and in the sheaths of muscles and tendons. It may arise from the formation of an excess of callus. Bruns claims that in fracture in the joint excess of callus rarely forms, and that masses of callus form chiefly in the line of fracture near but not in a joint.† Excessive callus-formation is sure to take place if reduction is not thoroughly accomplished or if the fragments are not well immobilized but move upon each other. A mass of callus in or about a joint limits or prevents motion.

* Transactions American Surgical Association, vol. ix.

† Max Oberst, in Volkmann's "Sammlung Vorträge."

Treatment of Fractures in or near the Elbow-joint.—Thoroughly set the fracture while the patient is under ether. It is advisable, when it can be done conveniently, to use the *x*-rays to confirm the diagnosis and to use them again after dressings have been applied, to be sure that the bones remain in good position. If swelling is very great, it may be necessary to delay setting for two or even three days, the arm being bandaged and laid upon a pillow or lightly supported on an anterior angular splint during the waiting period.

In all cases except transverse fracture above the condyles reduction is best effected by drawing upon the forearm, supinating it, extending it, and then bending it slowly into a position of acute flexion, the degree of flexion being in inverse ratio to the amount of swelling.

In transverse fracture above the condyles reduction is effected by drawing the forearm and the lower fragment downward and forward and at the same time pushing the upper fragment back.

Some surgeons advocate dressing the fracture on an anterior angular splint, the forearm being fully supinated. The advantage claimed for this splint is that if ankylosis occurs the joint is in a position to be useful, which it is not if ankylosed in extension. Some deformity is usually apparent after treating a case with this splint; the deformity following fracture of the inner condyle is not corrected by it, but if the splint is carefully applied the result is usually a useful extremity in all cases except fracture of the inner condyle. In transverse fracture of the shaft of the humerus above the condyles the anterior angular splint is the best method of treatment, as it prevents displacement. The splint must not be applied when there is great swelling, and swelling must be removed by resting the extremity on a pillow, the elbow being semiflexed, applying evaporating lotions or even an ice-bag, employing massage, and gently compressing by bandaging. In some cases the joint should be aspirated. In order to apply this dressing, take a right-angled splint and pad its outer surface, being careful to place thick, soft pads over the convexity which will press in front of the elbow and over each end of the splint. Fasten the upper end to the arm, then make extension of the forearm, and if the fracture is found to be well reduced, fasten the hand and forearm to the splint (Fig. 236). If the hand and forearm are first fixed to the splint, there will be no extension from the elbow and deformity will result. If posterior projection exists, a pasteboard cup is moulded over the elbow. The extremity is hung in a triangular sling. At night the extremity is kept in the sling or laid on a pillow. Every third or fourth day, while the extremity is carefully steadied, the splint is removed, the arm and forearm well rubbed with alcohol, massaged, and the splint reapplied. The splint is worn between five and six weeks. At the end of the third week, after removing the dressings, slightly flex, slightly extend, and slightly pronate the forearm, and reapply the splint. At the end of the fourth week repeat

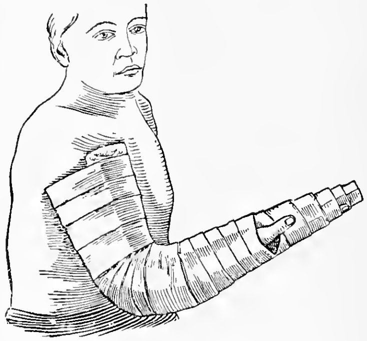


Fig. 236.—Anterior angular splint for fractures in or near the elbow-joint.

this maneuver, making movements of greater range. In the middle of the fifth week and at the end of the fifth week do it again, and flex and extend as much as possible. Very early and very frequent passive motion is objectionable, as it leads to overproduction of callus and ankylosis, but passive motion as above described is imperatively necessary. Many surgeons at the end of the second week apply a Stromeyer splint, which permits the patient and the surgeon to make some motion by means of the screw without removing the dressings. In very stout people an anterior angular splint will not stay in place. In such a case the forearm may be placed at a right angle to the arm and plaster-of-Paris be used. After the dressings are removed employ passive motion, massage, hot and cold douches, inunctions of ichthyol or mercurial ointment, iodin locally, corrosive sublimate and iodid of potassium internally, and direct the patient to systematically use the arm. If in any case after four weeks non-union exists, put up the arm in a plaster splint for three or four weeks more. Some surgeons use a posterior right-angled trough instead of an anterior angular splint (Fig. 229).

Fig. 237.—Frazier's modification of Jones's dressing for injuries of the elbow-joint.

Allis warmly advocates treatment in extension. He holds that the extended position secures the best circulation, and if either condyle is unbroken secures the benefit derivable from a natural splint. Furthermore, in fractures of the inner condyle, it restores the carrying function, which the flexed position does not do. For one week after the accident the patient stays in bed, with his arm extended upon a pillow. After swelling subsides the limb is wrapped firmly in a spiral flannel bandage and plaster is rubbed in or the bandage is covered with adhesive plaster.

Some surgeons extend the limb and apply an ordinary plaster bandage, and in about three weeks substitute an anterior angular splint. The trouble with treatment in extension is that if ankylosis ensues the limb is nearly useless. Furthermore, treatment by extension requires confinement to bed.

Jones, of Liverpool, thinks that splints and bandages are largely responsible for the stiffness which so commonly ensues upon an elbow injury. He advocates treatment by acute flexion in all elbow injuries except fracture of the olecranon. It has been demonstrated that the position of acute flexion forces the fragments into place and holds them firmly between the coronoid process of the ulna, the trochlear surface of the ulna, the fascia, and the triceps tendon. The surgeon must be certain that the radial pulse is perceptible *after* the elbow has been flexed. Flexion is maintained by fastening a bandage around the wrist and neck. The bandage around the neck passes through a rubber tube, which serves to protect the neck. The ball of the thumb should rest against the neck. The bandage is fastened to a leather band around the wrist. The most convenient dressing to maintain Jones's position was devised by Frazier; it is shown in Fig. 237.

After the dressing has been applied certain precautions are to be observed For the first week or ten days look at the arm daily. If the swelling grows worse, diminish the degree of flexion, and do the same if there is severe pain. If the radial pulse disappears, diminish the flexion until free circulation is obtained. This position is maintained from three to six weeks.* Passive motion and massage are applied as if an anterior splint were being used. The author has treated a number of cases by Jones's method, and now prefers it to any other plan in all fractures of the elbow except fracture of the olecranon and transverse fracture above the condyles. The former injury must be dressed in extension and the latter requires an anterior angular splint.

If it is found impossible to reduce the fragments or to maintain reduction we should follow the advice of John B. Roberts, make an incision and nail the fragments in place. A comminuted fracture requires operation.

In *young children* the anterior angular splint must not be used. It will become loosened, and motion will inevitably take place at the seat of fracture. Such cases can be treated satisfactorily in Jones's position with Frazier's sling, or we can treat them in extension. Bertomier's plan is very useful in young children.† The extremity is dressed without pressure in extension and supination. This can be effected by flannel bandages. In from four to eight days a silicate of sodium bandage is applied in order to prevent pronation. About the sixteenth day the bandage is cut so as to form two troughs. From this period every third day the splints are removed and gentle passive motion is made. The splints are removed permanently at the end of four weeks.

If *false ankylosis* follows fracture of the elbow, the adhesions should be broken up under ether, and for some time the hot-air apparatus should be used daily and massage, passive motion, and the hot and cold douche should be employed. In *true ankylosis* an operation should be performed and the interlocking callus or the interposed tissue or fragment removed, if a skiagraph shows that operation promises success. If gunstock deformity results and produces marked disablement, it should be operated upon. An osteotomy is performed on the inner condyle. The arm is set in the extended position, plaster-of-Paris applied, and is not removed for six weeks.‡

Separation of the lower epiphysis of the humerus is a not unusual accident. The inferior extremity of the humerus may be separated, or the condyles may be separated from each other and from the shaft of the bone.

Symptoms.—The symptoms are prominence in front of the joint, caused by the lower end of the shaft of the humerus; projection backward of the olecranon; the forearm rests midway between pronation and supination. Epiphyseal separation may retard growth and produce deformity.

Treatment.—Jones's position or an anterior splint as above directed.

Fractures of the ulna comprise the following varieties: (1) fracture of the coronoid process; (2) fracture of the olecranon process; (3) fracture of the shaft; and (4) fracture of the styloid process.

Fractures of the coronoid process of the ulna are rarely observed, and practically occur only as a complication of backward dislocation of the ulna or in association with other fractures.

* Provincial Medical Jour., Dec., 1894, and Jan., 1895.
† Révue de Chir., vol. viii, 1888.
‡ G. G. Davis, Phila. Med. Jour., May 13, 1889.

Symptoms.—When fracture of the coronoid process is associated with a dislocation, crepitus is appreciated on reduction, and it is found that the deformity of the dislocation promptly returns on cessation of extension. The upper fragment may be pulled upward by the brachialis anticus muscle, and there exists an inability to flex the forearm completely. The position is one of extension with posterior projection of the olecranon. The broken piece is felt in front of the joint.

Treatment.—The treatment is by an anterior splint the angle of which is less than a right angle. Jones's position may be used in treating such a case. A stiff joint may follow.

Fractures of the olecranon process of the ulna occur not uncommonly in adults. Hulke states that such a fracture never occurs before the age of fifteen, but the writer has seen in the Jefferson Medical College Hospital a girl aged fourteen with a fractured olecranon. The *cause* is direct violence or muscular action. Only a small fragment may be torn away, or the entire olecranon may be broken off, and the break may be comminuted or may even be compound.

Fig. 238.—Fracture between the condyles. Treated by Jones's position. Degree of voluntary flexion obtained.

Symptoms.—The symptoms of fracture of the olecranon are: swelling; partial flexion of the forearm; separation of the fragments, the upper piece being pulled up from half an inch to two inches by the triceps; the space between the fragments is increased by flexion at the elbow, and lessened by extension at the elbow; and there is inability to extend the arm. Bulging of the triceps above the fragments and crepitus on approximating the fragments are observed. In some few cases there is no separation, the periosteum being untorn or the fascial expansions from the triceps holding the fragments in apposition. In such cases crepitus can be elicited by rocking the upper fragment from side to side.

When treated by non-operative methods the *prognosis* is usually fair, fibrous union being the rule. Some joint-stiffness usually occurs, and much ankylosis may be unavoidable. The prospect of a freely movable joint is better when extra-articular wiring is practised.

Treatment.—Fracture of the olecranon is usually treated with a well-padded anterior splint almost, but not quite, straight. A perfectly straight splint is uncomfortable, and by opening a retiring angle between the fragments and into the joint favors non-union and ankylosis. The splint should reach from a level with the axillary margin to below the fingers. If the upper fragment does not come in contact with the lower, pull it down by adhesive plaster and fasten the strips to the splint. The author in one case employed a glove to which strings from the adhesive plaster were attached. After applying the splint keep the patient in bed for three weeks. The danger of anky-

losis in this fracture is very great, and, in case it occurs in the position of extension, an almost useless arm results. Follow the rule of T. Pickering Pick, and at the end of three weeks anesthetize the patient, press the thumb firmly down upon the top of the olecranon, put the forearm at a right angle, and

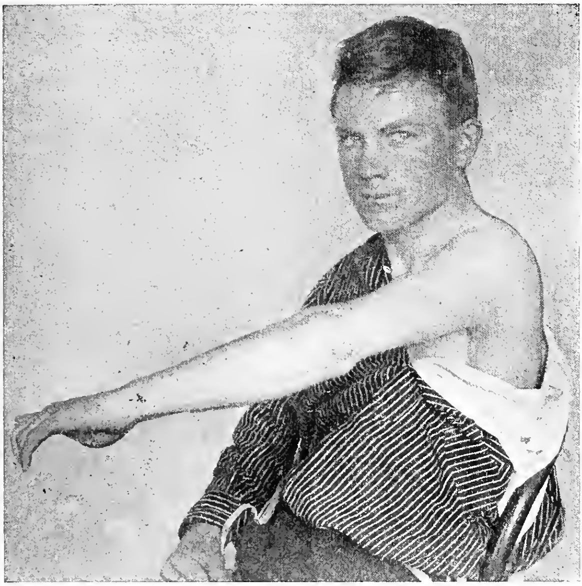


Fig. 239.—Fracture between the condyles. Treated by Jones's position. Degree of voluntary extension obtained.

apply an anterior angular splint and direct it to be worn for two weeks. When the anterior splint has been applied, passive motion should be made every other day, or every third day, and massage should be used at the same time. When the splint is removed, try to increase the range of motion as previously directed. Surgeons usually incise and apply wires only when it is found

Fig. 240.—Fracture of coronoid process.

impossible to secure apposition of the fragments after fracture of the olecranon. Such a course is, I am persuaded, injudicious conservatism. I do not advise that the rule should be to treat fracture of the olecranon as a routine by opening and wiring, but I do advise that we should treat them by extra-articular operation and wiring as advocated by John B. Murphy ("Jour.

Am. Med. Assoc.," Jan. 27, 1906). The conservative non-operative treatment often fails. Sometimes the fragments cannot be approximated, frequently they cannot be maintained in approximation, not unusually a stiff or actually ankylosed joint results. Murphy thus describes the operation which should be done ("Jour. Am. Med. Assoc.," Jan. 27, 1906). "A longitudinal incision $\frac{1}{3}$ of an inch long was made on the external aspect of the ulna, $\frac{1}{2}$ of an inch from its articular surface, and tissues were divided to the bone.

Fig. 241.—Fracture of the shaft of the ulna (case in the Pennsylvania Hospital; skiagraphed by Dr. Gaston Torrance).

A smaller incision was made on the corresponding inner side. I perforated the base of the olecranon with an eyelet drill, which ran transversely from outward inward. I threaded the drill with a fine aluminum-bronze wire, drawing it through this transverse canal. The wire was carried upward under the skin on the inner surface of the elbow and then drawn out through another small incision, $\frac{1}{16}$ of an inch, made at the level of the apex of the olecranon. The wire was then reinserted and directed transversely from inward outward, passing it through the tendon of the triceps above the olecranon, and then drawn out to corresponding outward point through

a very small incision similar to that made on the inner side. The wire was again reinserted and pushed downward under the skin until it was finally brought out through the initial external incision. The circle once completed, traction was exerted on the wire until I was sure that the two fragments were in perfect coaptation, the latter being easily and satisfactorily accomplished. The ends of the wire were twisted several times and then divided by scissors close to the bone. By this procedure the skin was incised at four points, the largest incision being $\frac{1}{3}$ of an inch in length." A compound fracture and a comminuted fracture always require an operation, in which the joint is freely opened. Non-union requires opening of the joint and wiring of the fragments.

Fractures of the shaft of the ulna alone are most usual near the middle of the bone, are always due to direct violence, and are not infrequently compound. An injury which breaks the ulna is very apt to break the radius also.

Symptoms.—By running the finger along the inner surface of the bone there are detected inequality and depression; crepitus and mobility are easily developed; there are pain and the evidence of direct violence. The long axis of the hand is not on a line with the long axis of the forearm, but is internal to it. If deformity exists, it is due to the lower fragment passing into the interosseous space because of the action of the pronator quadratus; the upper fragment, acted on by the brachialis anticus, passes a little forward (Fig. 241). The forearm at and below the seat of fracture is narrower and thicker than normal.

Treatment.—In treating fracture of the shaft of the ulna place the forearm midway between pronation and supination, so as to bring the fragments together and to obtain the widest possible interosseous space, and thus limit the danger of union taking place between the radius and ulna. The position midway between pronation and supination is obtained by flexing the forearm to a right angle with the arm and pointing the thumb to the nose. Take two well-padded straight splints, one long enough to reach from the inner condyle to below the fingers, the other from the outer condyle to below the wrist; place a long pad of lint over the interosseous space on the flexor side of the limb, and another on the extensor side; apply the splints and hang the forearm in a triangular sling (Fig. 242). Passive motion is to be made in the third week, and the splints are to be worn for four weeks. Fractures of the ulna can be treated very efficiently with plaster-of-Paris.

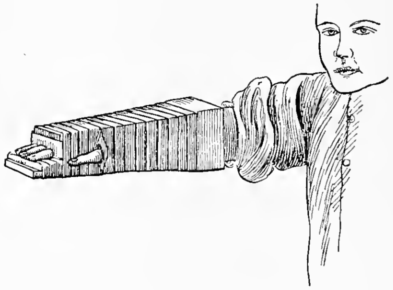


Fig. 242.—Two straight splints in fracture of both bones of the forearm.

Fractures of the styloid process of the ulna are due to direct force. The displacement is obvious.

Treatment.—In treating fracture of the styloid process push the fragment back into place and use a Bond splint with a compress for four weeks, or apply a plaster-of-Paris dressing.

Fractures of the radius include the following varieties: (*a*) fractures of its head; (*b*) fractures of its neck; (*c*) fractures of its shaft; and (*d*) fractures of its lower extremity.

Fracture of the head of the radius very rarely occurs alone, but it may complicate backward dislocation of the radius. Writers generally state that it is a very rare accident, but x-ray studies show it to be a not uncommon injury. It may be the sole injury or it may be associated with fracture of the external condyle of the humerus, fracture of the ulnar coronoid, backward dislocation of the radius, fracture of the neck of the radius, etc. The fracture may be a longitudinal split, a piece may be broken off, a wedge fracture may exist, or there may be comminution. The usual cause is a fall upon the extended hand ("Fractures of the Head of the Radius," by T. Turner Thomas, "University of Penn. Med. Bulletin," Sept. and Oct., 1905).

Fig. 243.—Impacted Colles's fracture.

Symptoms.—There may be crepitus on passive pronation and supination. In many cases there is swelling, acute pain on pressure over the radial head, no crepitus, normal continuity of head with the shaft, and loss of voluntary pronation and supination because of pain (T. Turner Thomas, *ibid.*). In such a case the diagnosis is made by the x-rays.

Treatment.—The treatment of a fracture of the head of the radius is the same as for a fracture in or near the elbow-joint, namely, an anterior angular splint, or placing the extremity in Jones's position.

Fracture of the neck of the radius is by no means as rare an accident as was thought before the discovery of the x-rays. It seldom occurs alone and is usually associated with fracture of the radial head. These fractures are frequently impacted. The cause is a fall upon the extended hand.

Symptoms.—In this fracture the forearm is pronated and the patient is found to have lost the power of voluntary pronation and supination. Under forced pronation and supination it will be noted that the head of the radius does not move and crepitus is felt. The lower fragment, being pulled upward and forward by the biceps, can be felt in front of the elbow-joint.

Treatment.—The treatment for fracture of the neck of the radius is the same as for fracture of the elbow-joint—namely, an anterior angular splint or Jones's position.

Fracture of the shaft of the radius is far commoner than fracture of the shaft of the ulna. It may occur above or below the insertion of the pronator radii teres muscle. It may arise from either direct or indirect force. Fracture of the shaft of the ulna may coexist as a result of the same accident.

Fracture of the Shaft of the Radius above the Insertion of the Pronator Radii Teres Muscle.—*Symptoms.*—The upper fragment is drawn

forward by the biceps and is fully supinated by the supinator brevis. The lower fragment is fully pronated by the pronator quadratus and pronator radii teres, and its upper end is pulled into the interosseous space. There are crepitus, mobility, pain, narrowing and thickening of the forearm below the seat of fracture, and loss of the power of pronation and supination. The head of the bone is motionless during passive pronation and supination. The hand is prone.

Treatment.—In treating this fracture do not put the forearm midway between pronation and supination, as this position will not bring the fragments into contact, the upper fragment remaining flexed and supinated. To bring the lower fragment in contact with the upper, flex and fully supinate the forearm. Apply an anterior angular splint to the extremity for four weeks, and make passive motion in the third week.

Fracture of the Shaft of the Radius below the Insertion of the Pronator Radii Teres Muscle.—In this variety of fracture the upper fragment is acted on by the biceps, the supinator brevis, and the pronator radii teres, and it remains about midway between pronation and supination, passing forward and also into the interosseous space. The lower fragment is acted on by the supinator longus and the pronator quadratus, the latter being the more powerful of the two, hence the lower fragment is moderately pronated, its upper extremity being drawn into the interosseous space. Other symptoms are identical with those of fracture above the insertion of the pronator radii teres.

Treatment.—In treating fracture below the pronator radii teres the forearm is flexed and is placed midway between pronation and supination; two interosseous pads and two straight splints are applied as for fracture of the ulna (Fig. 242). The splints are worn for four weeks, and passive motion is made in the third week. Plaster-of-Paris is a most satisfactory dressing.

Fracture of the shafts of both bones of the forearm is not frequently seen. It is caused by either direct or indirect force.

Symptoms.—After fracture of both bones of the forearm the hand is pronated and the two lower fragments come together and are drawn upward and backward or upward and forward by the combined force of flexor and extensor muscles, shortening being manifest and the projection of the lower fragments being detected on either the dorsal or the flexor surface of the forearm. The upper fragment of the ulna is somewhat flexed by the brachialis anticus; the upper fragment of the radius is flexed by the biceps and is pronated and drawn toward the ulna by the pronator radii teres. The forearm is narrower than it should be (the ends of the fragments having passed into the interosseous space) and is thicker than normal from front to back (the contents of the interosseous space having been forced out). Crepitus, mobility, pain, and inequality exist, the power of rotation is lost, and on passive rotation the head of the radius does not move. The forearm is prone and semiflexed.

Treatment.—The treatment consists in the application of two straight splints and two interosseous pads, the forearm being flexed to a right angle and placed midway between pronation and supination (Fig. 242). The splints are worn for four weeks, and passive motion is made in the third week. Instead of these splints, a plaster-of-Paris dressing can be used.

Fractures of the Lower Extremity of the Radius.—*Colles's fracture* is a

transverse or nearly transverse fracture of the lower end of the radius, between the limits of one-quarter of an inch and one and a half inches above the wrist-joint, the lower fragment sometimes mounting upon the dorsum of the upper fragment. An oblique fracture beginning within half an inch of the joint and passing into the joint is known as *Barton's fracture.* Colles's fracture was first recognized as a fracture by Colles, of Dublin, in 1814. Before his time the injury was called backward dislocation of the wrist. It is a very common injury, is met with most frequently in those beyond the age of forty, and oftener in women than in men. It is due to transmitted force (a fall upon the palm of the pronated hand). Some think that the force is received by the ball of the thumb and passes to the carpal bones and the edge of the radius; a fracture beginning posteriorly rather than anteriorly and the force driving the lower fragment upon the dorsal surface of the radius, the carpus and lower fragment moving upward and outward.

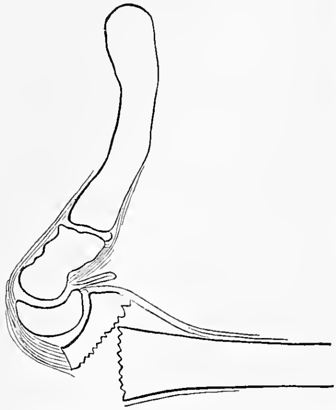
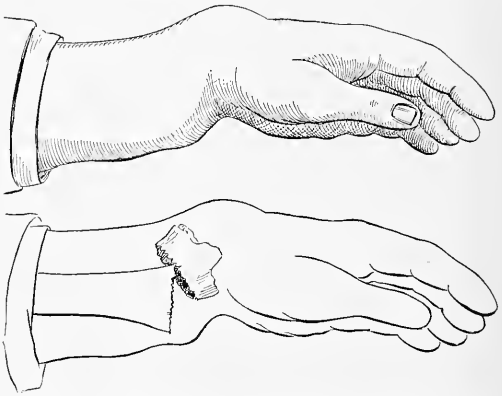


Fig. 244.—Effect upon the lower end of the radius of the cross-breaking strain produced by extreme backward flexion of the hand (Pilcher).

It is much more likely that this fracture is due to cross-strain on the bone. There is sudden traction upon the anterior ligaments, which drag upon the bone and break it at a point where the cancellous end of the radius joins the compact shaft (Fig. 244). The fragments are not unusually impacted. In the author's experience dislocation of the lower end of the ulna is a not unusual complication, which arises from a fracture of the ulnar styloid or tearing off of the internal lateral ligament of the wrist.



Figs. 245, 246.—Deformity at the wrist consequent upon displacement backward of the lower fragment of the radius after fracture at its lower extremity (Levis).

Symptoms.—In Colles's fracture the hand is abducted (drawn to the radial side of the forearm) and pronated, the head of the ulna is prominent, the styloid process of the radius is raised, and the lower fragment may mount on the back of the lower end of the upper fragment, causing a dorsal projection, termed by Liston the "silver-fork deformity" (Figs. 245 and 246). The lower end of the upper fragment can be felt beneath the flexor tendons above the wrist. The position in deformity is produced by the force. Some consider it is maintained by the action of the supinator longus and the flexor and

extensor muscles, but particularly by the extensors of the thumb. Pilcher has demonstrated the fact that in this fracture a portion of the dorsal periosteum is untorn, and this untorn portion acts as a binding band to hold the fragments in deformity. Pronation and supination are lost. In this fracture the hand can be greatly hyperextended (Maisonneuve's symptom). Crepitus, which is best obtained by alternate hyperextension and flexion, can be secured unless swelling is great or impaction exists. Crepitus on side movements is rarely obtainable. Impaction may greatly modify the deformity, though displacement generally exists to some extent, and the fragments do not ride easily on each other. The styloid process of the ulna may be broken, or the inferior radio-ulnar articulation may be separated. This latter complication allows the lower fragment to roll freely upon the upper, and the characteristic silver-fork deformity does not appear. If the styloid process of the ulna is

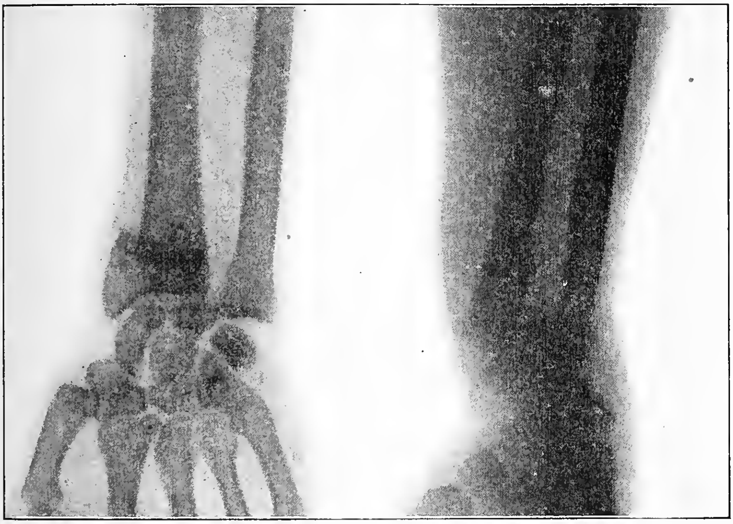


Fig. 247.—Colles's fracture of the radius (Pennsylvania Hospital case; skiagraphed by Dr. Gaston Torrance).

broken, pressure over it causes great pain. If a person in falling strikes the back of the hand and a fracture of the radius occurs, the lower fragment is driven upon the front surface of the upper fragment and is felt under the flexor tendons at the wrist. An elaborate study of fracture of the radius with forward displacement of the lower fragment has been published by John B. Roberts.*

Treatment.—In treating Colles's fracture reduce the deformity by hyperextension to unlock the fragments and relax the dorsal periosteum, and follow by longitudinal traction to separate the fragments, and forced flexion to force them into position. This formula was introduced many years ago by the late R. J. Levis. It is of the first importance to thoroughly reduce this fracture, and very often it is not thoroughly reduced. Imperfect reduction means permanent deformity, stiffness of the tendons and wrist, and possibly an almost useless hand. The extremity can be placed upon a Levis splint (Fig. 248), the posi-

*Am. Jour. Med. Sci., Jan., 1897.

tion maintaining reduction and the tense extensor tendons giving dorsal support. Some surgeons use Gordon's pistol-shaped splint. The favorite splint in Philadelphia practice in the past has been Bond's (Pl. 6, Fig. 7). It places the hand in a natural position of rest (semiflexion of the fingers, semi-extension of the wrist, and deviation of the hand toward the ulna). Two pads are used: a dorsal pad which overlies the lower fragment, and a pad for the flexor surface

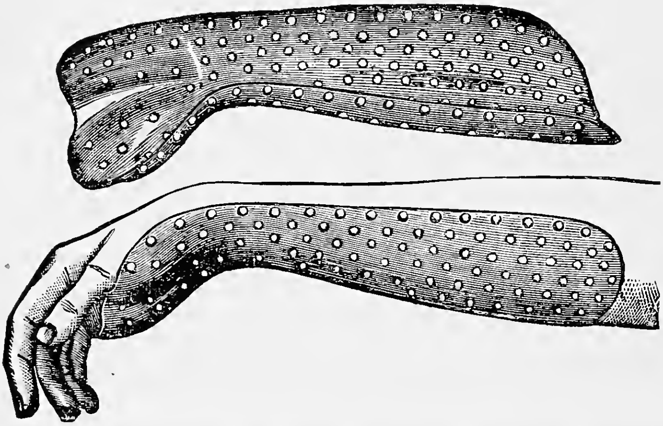


Fig. 248.—Levis's radius-splints, right and left, for fracture of the lower end of the radius.

which overlies the lower end of the upper fragment. A bandage is applied, the thumb and fingers being left free (Fig. 249). Passive motion is begun upon the fingers in three or four days, and upon the wrist during the second week. The splint is removed in three weeks, and a bandage is worn for a week or two more because of the swelling. In applying the Bond splint, do not pull the hand too much up on the block, or the fracture will unite with a projection upon the flexor surface of the extremity and the tendons of the wrist will be apt to be caught in the callus. The most satisfactory dressing is the straight dorsal splint advised by Roberts (Fig. 250). I use it almost invariably. It prevents the recurrence of deformity and is mechanically the proper mode of treatment. It should be worn for three weeks. Undoubtedly more or less stiffness often follows Colles's fracture, and some very able surgeons have been so impressed with the frequency of its occurrence that they have dispensed with the use of a splint. Sir Astley Cooper long ago spoke of placing the arm in a sling as proper treatment for fracture of the radius. Moore, of Rochester, applied a cylindrical compress over the ulna, held in place for six hours with adhesive plaster, then cut the plaster, placed the forearm in a sling, and let the hand hang over the edge of the sling. Pilcher applies a band of adhesive plaster around the

Fig. 249.—Bond's splint in Colles's fracture.

wrist and supports the wrist in a sling, but, as Storp says, dispensary patients are apt to disarrange this dressing. Storp wraps a piece of rubber plaster four inches wide around the wrist, and places a second piece around the first so arranged as to form a fold over the radius; an opening is made through the fold for the passage of a sling. In ten days the plaster is removed and the forearm is carried in a sling. If a stiff joint and limited tendon-motion eventuate from the fracture, use massage, frictions, sorbefacient ointments, tincture of iodin, electricity, hot and cold douches, and the hot-air apparatus, or give ether and forcibly break up adhesions. If reduction was not thoroughly effected and too great a length of time has not elapsed, and the hand is helpless and painful, the bone should be refractured. In a young or middle-aged person, in whom a useless hand has followed an ill-reduced fracture, osteotomy is justifiable.

Fracture of both the Radius and Ulna near the Wrist.—Colles's fracture may be complicated by a fracture of the ulna other than of its styloid process.

Symptoms.—In fracture of the radius and ulna near the wrist the lower ends of the upper fragments come together, the upper fragment of the radius is pro-

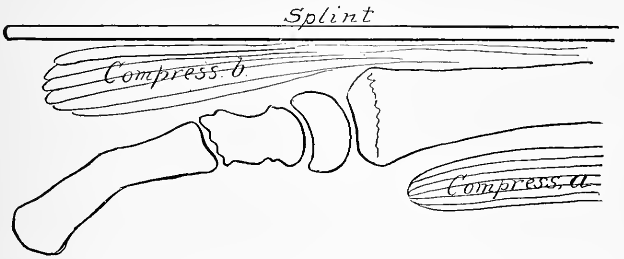


Fig. 250.—Diagram showing the arrangement of compresses and splint best adapted to retain fragments in proper position after reduction (Pilcher).

nated, and the lower fragment of the radius is drawn up. Pain, crepitus, mobility, shortening, and loss of function exist.

Treatment.—Fracture of the radius and ulna near the wrist should be treated with the straight dorsal splint, as in Colles's fracture.

Separation of the Lower Radial Epiphysis.—This accident occurs in children from falling upon the palm of the hand. It never happens after the twentieth year.

Symptoms.—In separation of the lower radial epiphysis the lower fragment mounts upon the upper and produces a dorsal projection like Colles's fracture, but the hand does not deviate to the radial side. The deformity resembles that of a backward carpal dislocation, but is differentiated from dislocation by the unaltered relation in the fracture between the styloid processes and the carpal bones.

Treatment.—The treatment in separation of the lower radial epiphysis is the same as for Colles's fracture.

Fractures of the carpus were until recently thought to be infrequent, but the *x*-rays have taught us differently, and we now know that many supposed sprains of the wrist are in reality simple fractures of the carpus. Codman

and Chase show that a majority of carpal injuries "are either simple fractures of the scaphoid or anterior dislocations of the semilunar bone," the two injuries being frequently combined ("The Diagnosis and Treatment of Fracture of the Carpal Scaphoid and Dislocation of the Semilunar Bone," Ernest Amory Codman and Henry Melville Chase, in "Annals of Surgery," March and June, 1905). The *cause* of carpal fractures may be violent direct force or falls upon the extended palm.

Symptoms.—Fractures of the carpus in general are indicated by pain, swelling, evidences of direct force, sometimes crepitus, loss of power in the hand, and a very little displacement.

Treatment.—Many compound comminuted fractures of the carpus require amputation. In an ordinary compound fracture asepticize, drain, dress with antiseptic gauze and a plaster-of-Paris bandage, cutting trap-doors in the plaster over the ends of the drainage-tube. In a simple fracture dress the hand upon a well-padded straight palmar splint (Pl. 6, Fig. 10) reaching from beyond the fingers to the middle of the forearm, and place the hand and forearm in a sling. The splint is worn for four weeks, and passive motion of the wrist is begun in the second week.

Fracture of the carpal scaphoid (see previously quoted article by Codman and Chase) usually results from falls upon the palm of the extended hand and is most common in males between the ages of twenty-five and thirty-five. It is rarely recognized at the time of the accident; the patient complains of severe pain, tenderness, and disability and is thought to have a sprain. According to Codman and Chase, the symptoms improve up to a certain point but not beyond it and the joint remains in a condition of irritation and weakness. After months or, perhaps, years, the diagnosis is made. In one case of my own, a locomotive engineer, the injury resulted from a blow on the palm with the reverse lever. He came to me three years after the injury when I recognized the condition as the one described by Codman and Chase. These writers say that the fingers are normally flexible, active and passive movements of the wrist are restricted to one-half or more of the normal excursion, and movements of flexion or extension beyond this are limited by muscular spasm, resembling the spasm occurring in a tuberculous joint. Any attempt to forcibly overcome the spasm produces violent pain. Crepitus is absent. The radial side of the wrist-joint exhibits some swelling, which obscures somewhat the flexor tendons of the thumb. There is tenderness on pressure over the scaphoid and it is most acute in the anatomical snuff box. The *x*-ray shows a transverse fracture of the scaphoid bone ("Annals of Surgery," March and June, 1905). Professor Dwight considers the above-described injury to be due to the two portions of the bone (there are two centers of ossification) having never formed a bony union and having been wrenched apart by violence. Codman believes the injury is the result of violence acting on a normal bone, the resulting non-union being due to lack of fixation and the presence of synovial fluid between the fragments.

The fracture may be accompanied by forward dislocation of the semilunar bone. If for several weeks after an accident causing fracture of the scaphoid the wrist is immobilized, union may occur, otherwise non-union will surely result.

Treatment.—This injury should be thought of when violence has been

applied to the carpus. It may be treated by a straight palmar splint if the case is seen early. If seen when there is non-union, the proximal half of the scaphoid should be excised (the incision being posterior and external to the extensor communis digitorum tendons) and passive motion should be begun within one week (Codman and Chase, in "Annals of Surgery," March and June, 1905).

Fractures of the Metacarpal Bones.—Fracture of the metacarpus is very common. One or more bones may be broken. The first metacarpal bone is oftenest broken; the third is seldom broken (Hulke). The *cause* is direct or indirect force. Fracture at the base of the first metacarpal bone was described by E. H. Bennett in 1881. It is called *Bennett's fracture*, or, as its discoverer named it, "*stave of the thumb.*" The fracture may be transverse at the neck or longitudinal, "the anterior basal projection being broken off" (Raymond Russ, in "Jour. Am. Med. Assoc.," June 16, 1906). This injury results from violent force applied to the distal end of the metacarpal (as in striking with the fist) or to the end of the extended thumb, and Russ regards it as the most common metacarpal fracture. It is usually mistaken for a sprain of the thumb and is sometimes regarded as subluxation backward of the first metacarpal.

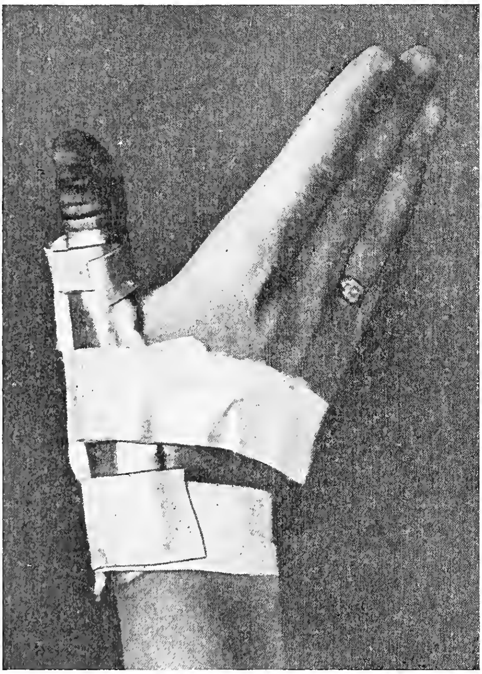


Fig. 251.—Coaptation-traction splint of Russ.

Symptoms.—The signs of a metacarpal fracture are—dorsal projection of the upper end of the lower fragment or the lower end of the upper fragment; pain; crepitus; and often evidences of direct violence. In fracture of the first metacarpal (Bennett's fracture) there is swelling, particularly evident in the flexor tendon sheaths on the thenar eminence (Russ), disability, pain, tenderness near the base of the metacarpal, and deformity, apparent shortening of thumb, and crepitus on reduction. The *x*-ray solves a doubtful case.

Treatment.—To treat a fracture of a metacarpal bone reduce by extension; place a large ball of oakum, cotton, or lint in the palm to maintain the natural rotundity, and apply a straight palmar splint like that used for fracture of the carpus. It may be necessary to apply a compress over the dorsal projection. The duration of treatment is three weeks, and passive motion is begun after two weeks. A plaster-of-Paris dressing is often used.

Raymond Russ ("Jour. Am. Med. Assoc.," June 16, 1906) describes the following splint as successfully used in a case of Bennett's fracture. I have used it in a case with much satisfaction. "The thumb was put in strong abduction and three wooden skewers—butcher's—neatly padded were placed about the metacarpal, one posteriorly in the interosseous space, one along the outer border, and the third over the thenar eminence. These extended from well above the metacarpal bone to the first phalangeal joint. They were fastened tightly in place by two strips of adhesive plaster. Traction was then exerted on the thumb and maintained by strips of adhesive plaster passing about the first phalanx and the projecting ends of the three skewers. This dressing was reinforced by a rectangular cardboard splint. Accurate coaptation and sufficient traction to overcome the deformity and muscular action are most necessary in the treatment of this fracture. Slate pencils or small lead pencils can be used in place of the wooden skewers. The soapstone slate pencils are less brittle than the ordinary kind."

Fractures of the Phalanges.—The phalanges are often broken. The fracture may be compound. The *cause* usually is direct force.

Symptoms.—Fracture of a phalangeal bone is indicated by pain, bruising, crepitus, and mobility, with very little or no displacement.

Treatment.—If the middle or distal phalanx is broken, mould on a trough-like splint of gutta-percha or of pasteboard, which splint need not reach into the palm. If the proximal phalanx is broken, carry the splint into the palm of the hand. Make the splint of gutta-percha, pasteboard, wood, or leather. The splint is worn three weeks. A sling must be worn, otherwise the finger will constantly be knocked and hurt. Some cases require a dorsal as well as a palmar splint. These cases are dressed most satisfactorily with a silicate of sodium or plaster-of-Paris bandage.

Fracture of the femur is a very common injury. The divisions of the femur are (1) the upper extremity; (2) the shaft; and (3) the lower extremity.

1. **Fractures of the upper extremity of the femur** are divided into: (*a*) intracapsular; (*b*) extracapsular; (*c*) of the great trochanter; and (*d*) epiphyseal separation (either of the great trochanter or the head).

Examination of the Hip.—It is sometimes though seldom necessary to give ether. Remove all the patient's clothing and place him recumbent upon a table. Note the position of the extremity. Feel with care the great trochanter and femoral neck. Very gradually and gently make movements to determine if there is impairment, undue mobility, or crepitus. Never make sudden or violent movements in looking for crepitus. The diagnosis can be made even if crepitus is not obtained, and rapid or violent movements may tear apart an impaction. Measure the sound extremity and the injured extremity. The measurement is made from the anterior superior spine of the ilium to the inner malleolus. Other symptoms to be looked for are set forth on pages 514 and 515.

Intracapsular Fracture of the Femur.—Intracapsular fracture of the neck of the femur is transverse or only slightly oblique (Fig. 252), and is not unusually impacted (Figs. 201, 202, 205). Stokes follows Gordon, of Belfast, in classifying fractures of the femoral neck. He divides them into intracapsular and extracapsular, and subdivides intracapsular fractures into fracture with penetration of the cervix into the head; fracture with reciprocal penetration;

intraperiosteal fracture at the junction of the cervix and head; intraperiosteal fracture of the center of the cervix; extraperiosteal fracture, with laceration of the cervical ligaments. The last-named fracture is the most common. The first four forms may unite by bone, the fifth form will not because of non-apposition, lack of nutrition, effusion of blood, synovitis, or interstitial absorption.* Stokes claims that we may have penetration, but not impaction. The *cause* is often slight indirect force, of the nature of a twist, acting upon a person of advanced years (more often a woman than a man), but not unusually a fall upon the great trochanter is the cause. A fall upon the knees,

Fig. 252.—Intracapsular fracture of the hip (Pennsylvania Hospital case; skiagraphed by Dr. Gaston Torrance).

a trip, or an attempt to prevent a fall may produce this fracture. It often happens that the fall is due to the fracture rather than that the fracture arises from the fall. Intracapsular fracture is never caused by direct force unless it is due to gunshot violence. The aged are more liable to intracapsular fracture than the young or the middle-aged, because, first, the angle which the neck forms with the axis of the femur becomes less obtuse with advancing years, and may even become a right angle; this change is more pronounced in women than in men; secondly, the compact tissue becomes thinned by absorption, the cancelli diminish, the spaces between them enlarge, the bony portions of the cancellous structure are thinned and destroyed,

* Stokes, in Brit. Med. Jour., Oct. 12, 1895.

and the cancellous structure becomes fatty and degenerated. The injury is not, however, limited to the aged. It has been positively shown that this fracture may occur in the young, even before the union of the epiphyses. In fact, fracture of the femoral neck is not very uncommon in children and in young and vigorous adults (Royal Whitman, "Med. Record," March 19, 1904). I have seen one case in a man of twenty-eight and several cases in those under forty-five. In the aged the fracture is, of course, complete, but in children and even in young adults it is usually incomplete, and for this reason the fracture is often not recognized in children and young adults.

Symptoms.—In intracapsular fracture there is usually *shortening* to the extent of from half an inch to an inch; but in some cases no shortening can be detected. Shortening of a quarter of an inch does not count in making a diagnosis, for one limb is often naturally a little shorter than the other. If the reflected portion of the capsule is not torn, the shortening is trivial in amount or is entirely absent. In some cases shortening gradually or suddenly increases some little time after the accident. This is due to separation of a penetration, tearing of the previously unlacerated fibrous synovial reflection, or restoration of muscular strength after traumatic paresis has passed away. A gradually increasing shortening arises from absorption of the head of the bone. Shortening is due chiefly to pulling upon the lower fragment by the hamstring, the glutei, and the rectus muscles.

Pain is usually present anteriorly, posteriorly, and to the side. The area of pain is localized, and motion or pressure greatly increases the suffering. Pain is not commonly severe except upon motion, when it may be localized in the joint. In some cases the pain is violent.

Eversion exists and is spoken of as "*helpless eversion,*" though in a very few instances the patient can still invert the leg. This eversion is due to the force of gravity, the limb rolling outward because the line of gravity has moved externally. That eversion is not due to the action of the external rotator muscles, as was taught by Astley Cooper, is proved by the fact that when a fracture happens in the shaft below the insertion of these muscles the lower fragment still rotates outward. This is further demonstrated by the considerations that the internal rotators are more powerful than the external, that some patients can still invert the limb after a fracture, and that eversion persists during anesthesia.* In some unusual cases *inversion* attends the fracture. Inversion, if it exists, is due to the fact that the limb was adducted and inverted at the time of the accident, and after the accident it remains in this position (Stokes). Besides shortening and eversion, the leg is somewhat flexed on the thigh and the thigh on the pelvis, the extremity when rolled out resting upon its outer surface. *Abduction* is commonly present.

Loss of power is a prominent symptom: the limb can rarely be raised or inverted; although in rare cases, when the fibrous synovial envelope is untorn, the patient may stand or even take steps. *Crepitus* often cannot be found, either because the fragments cannot be approximated, because penetration exists, or because the bone is greatly softened by fatty change. To obtain crepitus the front of the joint must be examined while the limb is extended and rotated inward. But why try to obtain crepitus? The diagnosis is readily

*Edmund Owen: "A Manual of Anatomy."

made without it; in many cases it cannot be detected, and the endeavor to obtain it inflicts pain and may produce damage. These fractures in the aged offer a not very flattering chance of repair, and efforts to find crepitus may produce serious damage. Limited abduction suggests impaction.

Altered Arc of Rotation of the Great Trochanter (*Desault's Sign*).—The pivot on which the great trochanter revolves is no longer the acetabulum, and the great trochanter no longer describes the segment of a circle, but rotates only as the apex of the femur, which rotates around its own axis. It is needless to try to obtain this sign; to do so inflicts violence on the parts.

Relaxation of the fascia lata (*Allis's sign*) simply means *shortening*. The fascia lata is attached to the ilium and the tibia (ilio-tibial band), and when shortening brings the tibia nearer to the ilium, this band relaxes and permits the surgeon to push his fingers more deeply inward on the injured side, between the great trochanter and the iliac crest, and near the knee above the outer condyle, than on the sound side. In this examination each limb should be adducted. Allis has pointed out another sign: when the patient is recumbent the sound thigh cannot be lifted to the perpendicular without flexing the leg; the injured thigh can be.

Lagoria's sign is relaxation of the extensor muscles.

Ascent of the Great Trochanter above Nélaton's Line.—This line is taken from the anterior superior iliac spine to the most prominent part of the ischial tuberosity (Fig. 253). In health the great trochanter is below, and in intracapsular fracture it is above, this line.

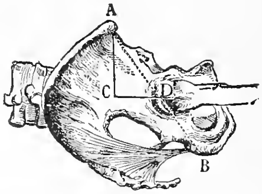


Fig. 253.—A C D, Bryant's ilio-femoral triangle; A B, Nélaton's line (Owen).

Relation of the Trochanter to Bryant's Triangle (Fig. 253).—Place the patient recumbent, carry a line around the body on a level with the anterior superior iliac spines, draw a line from the anterior iliac spine on each side to the summit of the corresponding great trochanter, and measure the base of the triangle from the great trochanter to the perpendicular line to determine the amount of ascent. The difference in measurement between the two sides shows the amount of ascent of the trochanter; that is, shows the extent of shortening.

Morris's measurement shows the extent of inward displacement. Measure from the median line of the body to a perpendicular line drawn through the trochanter on each side of the body.

Diagnosis.—The *x*-rays are a valuable aid to diagnosis (Fig. 252). Intracapsular fracture without separation of fragments may be mistaken for a mere contusion, and the diagnosis may continue obscure unless the fragments separate. Loss of function in contusion is rarely complete or prolonged, although occasionally the head of the bone is absorbed. Early after a contusion, and usually throughout the case, there is no alteration between the relation of the spine of the ilium and the trochanter, and no shortening. Some little time after a severe contusion the head of the bone may be absorbed. Contusion of a rheumatic joint leads to much difficulty in diagnosis. Intracapsular fracture may be confused with *extracapsular* fracture or with a dislocation of the hip-joint. Extracapsular fracture, which is common in advanced life, but is met with in middle life or even occasionally in the young, re-

sults usually from great violence over the great trochanter; if non-impacted, there are noted shortening of from one and a half to three inches, crepitus over the great trochanter, and usually, but not invariably, eversion; if impacted, there is less eversion, crepitus is almost or entirely absent, and the shortening is limited to about an inch. The extensor muscles are relaxed. Great tenderness exists over the great trochanter in both impacted and non-impacted fractures. In dislocation on the dorsum of the ilium the patient is usually a strong young adult. There is a history of forcible internal rotation. There are inversion (the ball of the great toe resting on the instep of the sound foot), rigidity, ascent of the great trochanter above Nélaton's line, and shortening of from one to three inches. The head of the bone is felt on the dorsum of the ilium, and the trochanter mounts up toward the spine of the ilium, and pressure upon it causes no pain. In dislocation into the thyroid notch there is possibly eversion, but it is linked with lengthening.

In *fracture of the brim of the acetabulum* there is shortening, which occurs on the removal of extension, inversion, abduction, flexion of the knee, the head of bone is drawn upward and backward with the acetabular fragment, and there is retention of the power of eversion and of adduction (Stokes). Crepitus is most distinctly appreciated by a hand resting on the ilium. In fracture of the fundus of the acetabulum there is shortening, and the head of the bone enters the pelvis (Stokes).

Prognosis.—The prognosis is not very favorable. Some aged patients die in a day or two from shock. Not a few perish later from hypostatic congestion of the lungs, kidney failure, or exhaustion. The majority of cases recover with a little shortening, some stiffness, and a permanent limp. There is a much better chance for firm union if the fracture is impacted than if it is not. Even if non-union results after an intracapsular fracture, and it is not unusual, a patient may get about fairly well with a proper support. In some cases after intracapsular fracture rheumatoid arthritis develops. Many surgeons have maintained that bony union never occurs, but it certainly does sometimes take place. Stokes holds that bony union is possible in fractures with penetration, and even in fractures without penetration when the fracture is within the periosteum.*

Treatment.—In treating a very feeble old person for intracapsular fracture make no attempt to obtain union. Keep the patient in bed for two weeks; give lateral support by sand-bags; tie around the ankle a fillet, attach a weight of a few pounds to the fillet, and hang the weight over the foot-board of the bed. When pain and tenderness abate, order the patient to get into a reclining-chair, and permit him very soon to get about on crutches. If hypostatic congestion of the lungs sets in, if bed-sores appear, if the appetite and digestion utterly fail, or if diarrhea persists, abandon attempts at cure in any case, and get the patient up and take him into the sunshine and fresh air, simply immobilizing the fracture as thoroughly as possible by means of pasteboard splints or plaster-of-Paris. In the vast majority of cases, no matter how old the patient may be, undertake treatment. We may be forced to abandon it, but should at least attempt to obtain a cure. If it is determined to treat the case, place the patient on a hair mattress, several boards being laid under the mattress transversely in order to prevent unevenness and the formation of hollows. A fracture-bed is a valuable adjunct to treatment

*See the masterly paper by Stokes, before quoted.

Treatment by the extension apparatus of Gurdon Buck: Extend the knee, and place the leg in a natural posture, and put a pillow beneath the knee. Combine extension with lateral support by means of sand-bags. The extension should be gentle, never forcible. It is not wise to pull apart a penetration in an old person, but it should always be done in a young or middle-aged person. Place the subject on a firm mattress. If the patient be a man, shave the leg. Cut a foot-piece out of a cigar-box, perforate it to admit the passage of a cord, wrap it with adhesive plaster as shown in Plate 6, Figs. 15 and 16, run the weight-cord through the opening in the wood, and fasten a piece of adhesive plaster on each side of the leg, from just below the seat of fracture to above the malleolus (Pl. 6, Fig. 14). The plaster is guarded from sticking to the malleoli by having another piece stuck to its under surface opposite each of these points. Apply an ascending spiral reversed bandage over the plaster to the groin (Fig. 254), and finish the bandage by a spica of the groin. Slightly abduct the extremity. Put a brick under each leg of the bed at its foot, thus obtaining counter-extension by the weight of the body. Run a cord over a pulley at the foot of the bed, and obtain extension by the use of weights. In an adult from fifteen to twenty pounds will probably be necessary at first, but after a few days from eight to ten pounds will be

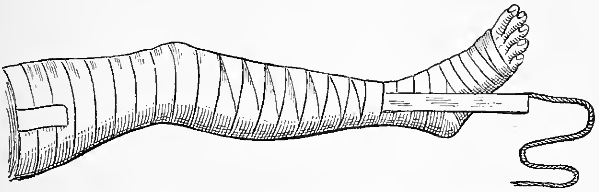


Fig. 254.—Adhesive plaster applied to make extension.

found sufficient (remember that a brick weighs about five pounds). Dawbarn's rule as to the proper weight to be attached is one pound for every year up to twenty. When the foot of the bed is raised and the weight to make extension is applied, very gently rotate the extremity, put the foot at a right angle with the leg, and make a bird's-nest pad of cotton or oakum to save the heel from pressure. Take two canvas bags, one long enough to reach from the crest of the ilium to the outer malleolus, the other long enough to reach from the perineum to the inner malleolus. Fill the bags three-quarters full of dry sand, sew up their ends, cover the bags with slips, and put the bags in place in order to correct eversion. The slips may be changed every third or fourth day. Keep the bed-clothing from coming in contact with the foot by means of a cradle (Figs. 255, 256). The bowels are to be emptied and the urine is to be voided in a bed-pan, unless using a fracture-bed. For two weeks the patient remains recumbent, after which time he can be propped up on pillows. Maintain extension for three weeks, then simply maintain support by sand-bags or mound pasteboard splints upon the part, and keep up this support three to five weeks more. After removing the extension he can be transferred daily to a couch. In from six to eight weeks after the infliction of the injury he can be moved about in a wheeling-

chair, the leg being extended or the knee flexed in accordance with the dictates of comfort. After a week or so of such movement a thick-soled shoe is placed on the sound foot and the patient is allowed to use crutches; but weight is not put upon the injured extremity until from ten to twelve weeks have elapsed from the time of the accident. For many months, at least, and possibly permanently, he walks with the aid of a cane. Union, if it takes place, is usually cartilaginous, but is sometimes bony, and there will surely be some shortening and also some stiffness of the joint. Passive motion is not made until at least eight weeks have elapsed since the accident. Treatment by the extension apparatus is far from satisfactory, as it does not afford sufficient immobilization.

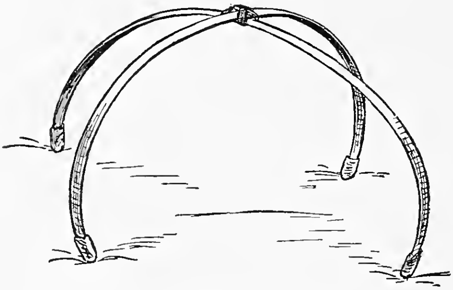


Fig. 255.

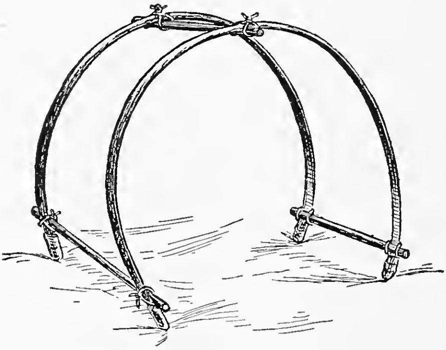


Fig. 256.

Figs. 255, 256.—Cradle to keep clothing from leg, made from two barrel-hoops (Scudder).

Senn's method: Senn claims that by this method of "immediate reduction and permanent fixation" bony union is obtained in fractures of the neck of the femur within the capsule. He "places the patient in the erect position, causing him to stand with his sound leg upon a stool or box about two feet in height; in this position he is supported by a person on each side until the dressing has been applied and the plaster has set.

"Another person takes care of the fractured limb, which in impacted fractures is gently supported and immovably held until permanent fixation has been secured by the dressing. In non-impacted fractures the weight of the fractured limb makes auto-extension, which is often quite sufficient to

restore the normal length of the limb; if this is not the case, the person who has charge of the limb makes traction until all shortening has been overcome as far as possible, at the same time holding the limb in position, so that the great toe is on a straight line with the inner margin of the patella and the anterior superior spinous process of the ilium. In applying the plaster-of-Paris bandages over the seat of fracture a fenestrum, corresponding in size to the dimensions of the compress with which the lateral pressure is to be made, is left open over the great trochanter.

"To secure perfect immobility at the seat of fractures, it is not only necessary to include in the dressing the fractured limb and the entire pelvis, but it is absolutely necessary to also include the opposite limb as far as the knee and to extend the dressing as far as the cartilage of the eighth rib.

"The splint (Fig. 257) is incorporated in the plaster-of-Paris dressing, and it must carefully be applied, so that the compress, composed of a well-cushioned pad with a stiff, unyielding back, rests directly upon the trochanter major, and the pressure, which is made by a set-screw, is directed in the axis of the femoral neck. Lateral pressure is not applied until the plaster has completely set. Syncope should be guarded against by the administration of stimulants.

"As soon as the plaster has sufficiently hardened to retain the limb in proper position the patient should be laid upon a smooth, even mattress, without pillows under the head, and in non-impacted fractures the foot is held in a straight position and extension is kept up until lateral pressure can be applied.

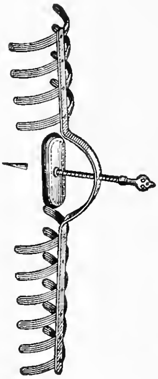


Fig. 257.—Senn's apparatus.

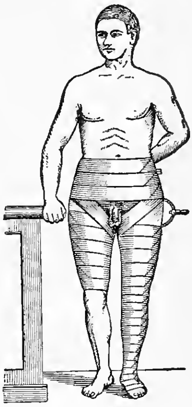


Fig. 258.—Senn's apparatus applied.

"No matter how snugly a plaster-of-Paris dressing is applied, as the result of shrinkage it becomes loose, and without some means of making lateral pressure it would become necessary to change it from time to time in order to render it efficient. But by incorporating a splint in the plaster dressing (Fig. 258) this is obviated, and the lateral pressure is regulated, day by day, by moving the screw, the proximal end of which rests on an oval depression in the center of the pad."

Treatment by Thomas's splint: Scudder, in his valuable treatise on "The Treatment of Fractures," advocates in intracapsular fracture the use of Thomas's hip splint. If the bones are unimpacted, the fragments are brought into apposition by extension, inversion, and pressure upon the great trochanter, and the Thomas splint is bent to fit, is padded, and is applied (Figs. 261, 262). When the bed-pan is to be used or the bed is to be smoothed, the patient can be lifted without disturbing the fracture. He can be turned on the sound side. If hypostatic congestion is developing, raise the head of the bed and tie the splint to the iron of the head of the bed. In addition to the use of the splint Scudder advocates the making of lateral pressure over the great trochanter by a graduated compress and a bandage. The splint is

worn for six or eight weeks. It is then removed, the patient remaining in bed four weeks longer without any apparatus (Scudder, from Ridlon).

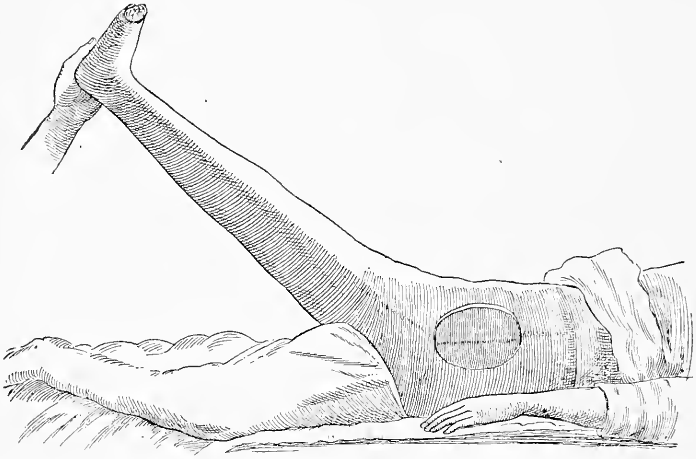


Fig. 259.—The long spica as applied for fracture of the neck of the femur in the adult; illustrating the advantage of an appliance which permits movement without danger of displacing the fragments; an opening has been made to lessen the constriction of the abdomen (Whitman).

Whitman's Treatment in Abduction: The plan advocated by Royal Whitman ("Med. Record," March 19, 1904) is a most excellent one. It aims to abolish traumatic depression of the neck of the femur.

We can apply this plan in a young person to any fracture even if impacted. In an aged person we apply it only in a complete non-impacted fracture. In a young person we give ether and pull apart an impaction by abduction. In an aged person we should not do so.

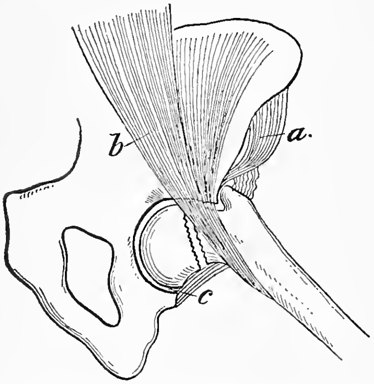


Fig. 260.—Reduction and fixation in abduction, showing security assured by direct bony contact of the neck and trochanter with the pelvis, also the effect of the attitude on muscular action (Whitman). *a*, Abductor group; *b*, ilio-psoas; *c*, capsule.

The extremity is set in extension and extreme abduction and plaster-of-Paris is applied. The tension of the capsule pushes the outer fragment against the inner and holds it; fixation is obtained by the neck of the femur being in contact with the acetabulum and the great trochanter with the pelvis, deformity cannot be caused by muscular action, and the psoas helps pull the fragments together (Whitman).

Extracapsular Fracture (*Fracture of the Base of the Neck of the Femur*).—The line of extracapsular fracture is at the junction of the neck with the great trochanter, and is partly within and partly without the capsule, the fracture being generally comminuted and often

impacted. The *cause* is violent direct force over the great trochanter (as by falling upon the side of the hip). This fracture is most usual in elderly people, but is not very uncommon in young adults. Stokes has described six forms of extracapsular fracture: extracapsular fracture with partial impaction posterior; fracture with complete impaction; fracture with partial impaction above; fracture with partial impaction below, the shaft being split; splitting the neck longitudinally without impaction; comminuted non-impacted fracture.*

Symptoms.—When impaction is absent there is marked crepitus on motion, which is manifested most distinctly when the fingers are placed upon the great trochanter; there is severe pain, pressure upon the great trochanter is very painful, swelling and ecchymosis are marked; there is absolute inability on the part of the patient to move the limb, and passive movements cause violent pain; there is shortening to the extent of at least

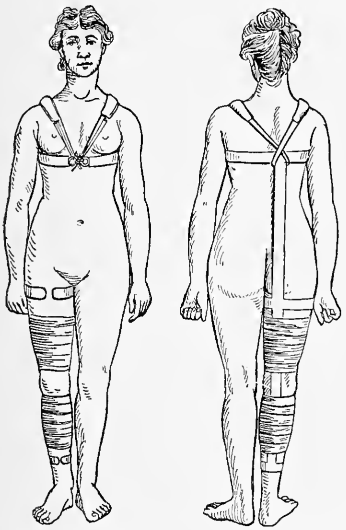


Fig. 261.—Thomas's single hip-splint in position (Ridlon).

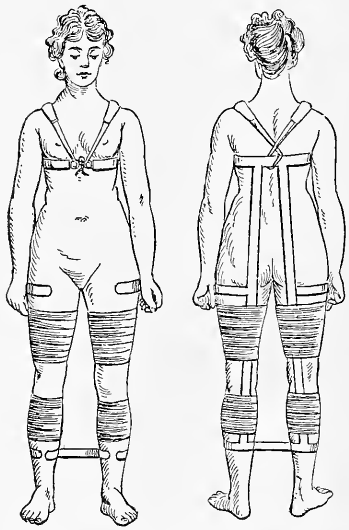


Fig. 262.—Thomas's double hip-splint in position (Ridlon).

one and a half inches, and sometimes to the extent of three inches, which shortening is made manifest by noting the ascent of the trochanter above Nélaton's line, by a comparison of measurements of the injured limb and the sound limb, and by measuring the base-line of Bryant's triangle on each side. Absolute eversion usually exists with slight flexion both of the leg and the thigh. In some rare cases there is inversion. This happens if at the time of the accident the limb was inverted and adducted (Stokes). Lagoria's sign, Desault's sign, and Allis's signs are present. All these symptoms follow violent direct lateral force. In the *impacted* form of extracapsular fracture, in addition to the aid given the surgeon by the history, there is severe pain, which is intensified by movement or pressure; shortening to the extent of one inch at least, which is not corrected by extension; limited abduction; great loss of function; and whereas the limb may be straight or even inverted,

* Brit. Med. Jour., Oct. 12, 1895.

it is usually everted. The trochanter is above Nélaton's line, the base-line of Bryant's triangle is shortened, but not so much as in the unimpacted form; there is no crepitus unless the impaction is pulled apart, and the arc of rotation of the great trochanter is larger than in a non-impacted fracture.

Treatment.—In impacted extracapsular fracture it is best to pull apart the impaction if the patient is in good physical condition. Southam, of Manchester, in an impressive article, has recently insisted on the absolute necessity of pulling apart an impaction. He gives ether, and when the patient is anesthetized unlocks the fragments.* This unlocking is best accomplished by abduction, the rim of the acetabulum acting as the fulcrum of the lever (Whitman). In treating non-impacted extracapsular fracture make extension, raise the foot of the bed, and apply the extension apparatus with sand-bags for three weeks and then apply a plaster dressing. Get the patient on crutches after the plaster has been in place for two weeks. Remove the plaster at the end of four weeks. Thomas's splint may be used instead of Buck's extension or the treatment suggested by Whitman may be employed (page 520).

Fractures of the Femoral Neck in Children.—Fracture of the femoral neck in children and in young adults can scarcely be regarded as very unusual, and is certainly more often encountered than is separation of the upper epiphysis. The accident results from a fall rather than, as in an adult, from a twist, and it is the product of considerable violence rather than of slight force. In children such fractures may be impacted and most of those which are unimpacted are of the green-stick variety. The disability is not nearly so great as in an adult; in fact, it is not unusual for the victim of such an injury to be able to hobble about a few days afterward. The symptoms are shortening, some eversion, impairment of joint-movements, and a limp when the patient gets about. Fractures of the hip in children are often unrecognized and lead frequently to permanent impairment because of the development of coxa vara. The *x*-rays should be used in making the diagnosis.

A green-stick fracture may be treated with Thomas's splint, and after four weeks in bed "the child may be allowed up, wearing a traction hip-splint for several months until union is so firm that the danger from coxa vara is practically eliminated. A light plaster-of-Paris spica bandage from the calf to the axilla will maintain immobility after the splint is omitted" (Scudder, on "The Treatment of Fractures"). An impacted fracture, after the impaction has been pulled apart, is treated exactly as is a green-stick fracture. Royal Whitman's plan for treating a green-stick fracture is very satisfactory. This surgeon ("Med. Record," March 19, 1904) dresses these cases by placing the limb in extreme abduction and holding it so by means of a plaster-of-Paris spica (Figs. 259, 260). In a case of acute disability of the hip-joint in a child, following some time after fracture of the femoral neck, make a careful differentiation from tuberculous disease of the joint and apply a traction splint to support the body and give rest to the joint. If coxa vara becomes marked and causes great disability, osteotomy is justifiable.

Separation of the upper epiphysis of the femoral head is a very rare result of accident; it occurs most often from disease. It is met with in early youth, results in considerable permanent shortening and perhaps in coxa vara.

Symptoms and Treatment.—The symptoms are like those of fracture of the neck, except that the crepitus is soft. The *treatment* is as above directed.

* Lancet, Dec. 21, 1895.

Fractures of the Great Trochanter.—This process may be (1) broken off without any other injury, but in most cases (2) the line of fracture runs through the trochanter, and leaves one portion of the trochanter attached to the head and neck and the other part attached to the shaft of the femur. The *cause* is violent direct force over the great trochanter.

Symptoms and Treatment.—The symptoms of the second form are similar to those of extracapsular fracture. On rotating the femur the lower part of the trochanter moves with it, but not the upper. The lower fragment goes upward and backward and projects by the side of the sciatic notch. There are shortening, eversion, crepitus, and altered position of the trochanter.

Fig. 263.—Deformity following fracture of upper third of femur.

The symptoms of the first form resemble those of epiphyseal separation. The *treatment* of the second form is like that in extracapsular fracture, and the first form is treated like separation of the epiphysis of the trochanter.

Separation of the epiphysis of the great trochanter is a very rare accident. The *cause* is direct violence, and the injury occurs only in youth.

Symptoms.—The trochanter is found to have ascended and passed posteriorly; there is no shortening of the thigh; all the motions of the hip-joint can be obtained; if the thigh is flexed, abducted, and rotated externally,

and the fragment is pushed downward and forward, crepitus is obtained—soft in epiphyseal separation, hard in fracture.

Treatment.—In treating separation of the epiphysis of the great trochanter flex the leg on the thigh and the thigh on the pelvis, place the extremity upon its outer surface, keep it fixed by some form of retentive apparatus, and try to draw the trochanter downward and forward by adhesive strips or by a pad and bandage. Some degree of lameness is inevitable, even after Bryant's extension. Bryant's extension directly upward may admit of the trochanter being pulled into place upon the bone (Fig. 268). Extension must be applied for four weeks, and crutches and pasteboard splints should be used for four weeks more. Nailing the epiphysis in place should give a better result than conservative treatment.

2. **Fractures of the shaft of the femur** may affect any portion of the shaft, but especially the middle third, and may occur at any age. Fracture of the upper third is a rare accident. Allis estimates that each year in Philadelphia there is 1 case of fracture of the upper third of the femur to every 100,000 inhabitants. Separation of the lower epiphysis occasionally occurs. The *cause* of fractures in the upper third is usually indirect force; fractures in the lower third are due to direct force; and in fractures of the middle third these two causes are about equally potential. Fracture from muscular action occasionally occurs. Oblique fracture is the usual variety. In many cases the soft parts are badly lacerated and sometimes a great vessel is torn.

Symptoms.—The chief symptom in fracture of the shaft of the femur is great displacement, except when impaction occurs, when the break is due to direct force, or when the injury is in a child. In a child the line of fracture is often transverse and the periosteum may be untorn. Green-stick fractures occur in children. As a rule, in fracture of the shaft of the femur the lower fragment is drawn upward and the upper end of the lower fragment is found posterior and somewhat to the inside of the lower end of the upper fragment, and the lower fragment also undergoes external rotation (the drawing up is due to the rectus and hamstrings; the passing inward is due to the adductor muscles; the rotation outward arises from the weight of the limb). If a fracture of the lower two-thirds of the shaft is produced by direct force, there is usually but little deformity, because the line of fracture is nearly transverse. If produced by indirect force, there is often great deformity, the line of fracture being oblique. In fracture of the lower third of the shaft the gastrocnemius pulls upon the condyles and tilts the lower fragment, so that its upper end projects into the popliteal space and may damage the vessels. In fracture of the upper third the upper fragment is apt to be thrown strongly forward and outward (Fig. 263). Some attribute this to the action of the psoas, iliacus, and external rotator muscles, but Allis thinks it is due chiefly to the lower fragment pushing the upper fragment into this position, a part of the tendon of the gluteus maximus acting as a hinge for the fragments.* In rare cases the angular deformity is backward. In fracture of the shaft of the femur there is complete loss of function, the thigh and leg are slightly flexed and usually everted. In some cases the leg and lower fragment are inverted. There are shortening to the extent of two or

* "Fracture in the Upper Third of the Femur Exclusive of the Neck," by Oscar H. Allis, Medical News, Nov. 21, 1891.

three inches, pain on movement, preternatural mobility, crepitus, and obvious deformity, and the ends of the fragments can be felt by the surgeon. In impaction there is alteration of the axis of the limb and some shortening. Always feel for the pulse below the fracture to learn if the artery is damaged.

Treatment.—In setting and dressing a fracture of the thigh ether should be given and the parts must be handled with great care to prevent a sharp end of bone from tearing the soft parts and puncturing the skin.

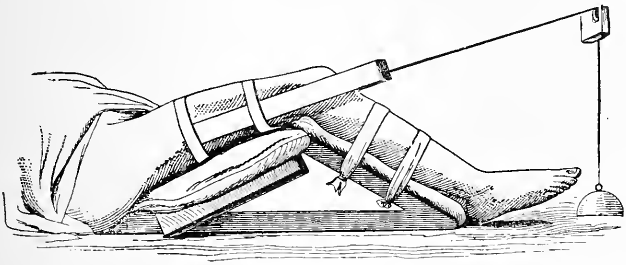


Fig. 264.—Dressing of fracture of the femur in the upper third with extension upon a double inclined plane (Agnew).

In fracture of the shaft of the femur, if impaction exists, the fragments must be pulled apart, when the case should be treated exactly as is a non-impacted fracture. After a fracture of the shaft of the femur some amount of permanent shortening is almost inevitable. In *fracture of the upper third* treatment is usually unsatisfactory, and there is permanent shortening from angular union or from overlapping. Horizontal extension fails to correct the displacement of the upper fragment in fracture of the upper third. The double inclined plane will not correct the tilting of the upper fragment while shortening exists. Agnew used a double inclined plane and corrected shortening by the use of extension in the axis of the partly flexed thigh (Fig. 264). This plan is the most serviceable of those usually employed, but it too fails to completely correct the displacement. If, notwithstanding position and extension, the upper fragment projects, it should be pushed into place and be retained if possible by short splints bound upon the thigh. Extension should be continued for four weeks, a plaster-of-Paris bandage being used for four weeks more, the patient being then allowed to go about on crutches. Some surgeons, in fracture of the upper third, apply a plaster-of-Paris bandage to the leg, thigh, and pelvis, extension being made from the foot while the dressing is being applied. This method does not give good results because such extension will not correct the tilting of the upper fragment. The anterior

Fig. 265.—Smith's anterior splint.

splint of Nathan R. Smith is used by some in treating fractures of the upper third of the femur (Fig. 265). It is bent to the desired shape, fastened to the anterior surfaces of the leg and thigh, and hung to a gallows, the limb being suspended at the desired height. This splint is open to the same objection as the double inclined plane. In fact, in many fractures of the upper third of the shaft of the femur no apparatus will maintain reduction. In such cases it is advisable to incise, separate the muscles from between

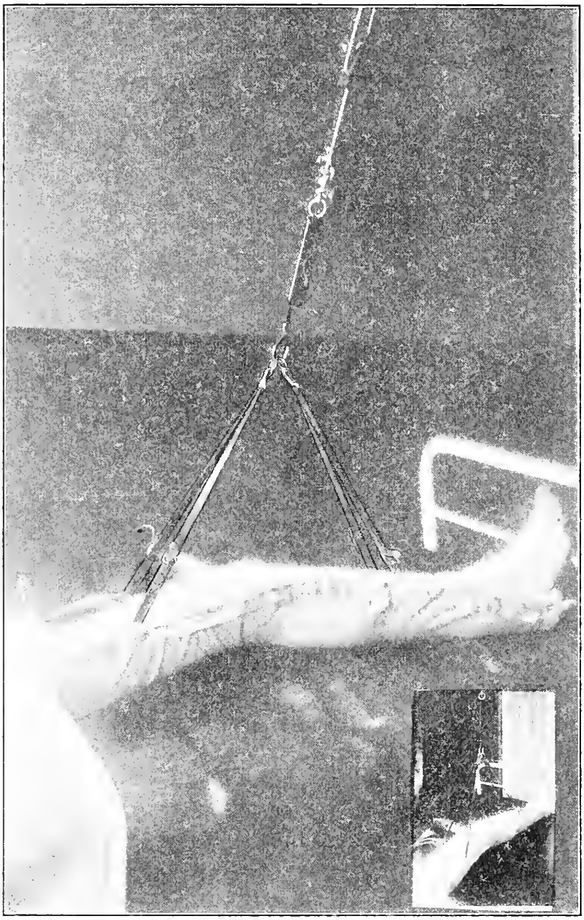


Fig. 266.—Hodgen's apparatus as applied by Dr. George S. Brown.

the fragments, and fasten the ends of the bone fragments together with bone ferrules, silver wire, kangaroo-tendon, steel screws, steel pins, or a bone-clamp. This radical treatment has certain dangers of its own, but it is the only plan which promises to secure a thoroughly good limb. In *fracture* of the *middle third* or *upper part of the lower third* of the shaft of the femur, the extension apparatus and sand-bags will usually secure a satisfactory result (Pl. 6, Fig. 14). The strips of adhesive plaster are carried to

just below the seat of fracture, and the turns of the roller bandage should be taken to a little above this point. Extension should be continued for four weeks, when the plaster-of-Paris bandage ought to be applied. The plaster is kept in place for four weeks. Many surgeons use Hodgen's splint in treating fractures of the thigh. The limb is suspended in a cradle and extension is obtained by strapping the foot to the cross-bar of the frame and pulling upon the frame by cords (Fig. 266). Hodgen's apparatus as applied by Brown, of Birmingham, Ala., is one of the most satisfactory methods of treatment in fracture below the upper third. The extremity can be raised or lowered at will without disturbing the approximation of the fragments, extension to the required degree can be obtained, and the patient can be moved in bed. I consider this apparatus the most comfortable appliance which can be worn and excellent results are obtained by its use. In fracture of the middle third or upper part of the lower third of the shaft if the line of fracture is transverse and there is little deformity, as is seen often after a fracture by direct force, and often in children, immobilization in an im-

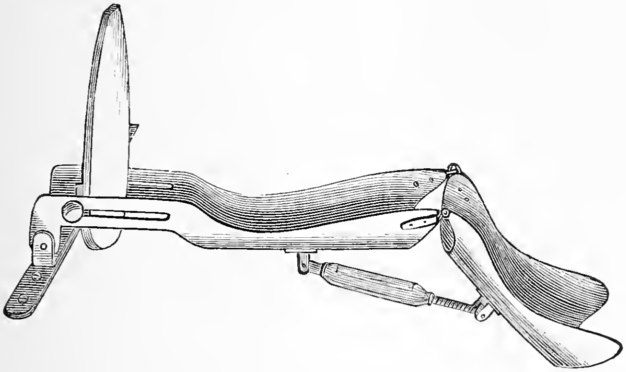


Fig. 267.—McIntyre's splint.

movable dressing may be all that is required; but if shortening exists, extension must be used. If extension is used, continue it for four weeks and then substitute a plaster-of-Paris dressing for four weeks. The amount of weight required is pointed out by Dawbarn—one pound for each year up to twenty.* In *fracture near the knee-joint* (*lower part* of the *lower third* of the femur) it may be impossible to effect reduction by horizontal traction. In such a case make traction, and while it is being made gradually bring the leg to a right angle. Place the limb in a double inclined plane (Pl. 6, Fig. 2). A McIntyre splint (Fig. 267) is a useful form of double inclined plane. After four weeks of the use of a double inclined plane apply a plaster-of-Paris dressing, which is to be worn for four weeks.

Fractures of the Shaft of the Femur in Children.—In children under three years of age the extension apparatus will not satisfactorily immobilize the fragments. Fractures of the thigh in children are reduced by extension and counter-extension; a well-padded splint reaching from the axilla to below the sole of the foot may be applied to the outer side of the limb and body. This splint is held in place by bandages which are overlaid with plaster-of-Paris.

* Annals of Surgery, Oct., 1897.

It is worn for four weeks, at which time it is removed and a plaster bandage, applied so as to include the entire limb, is worn for four weeks more.

Bryant's extension is very satisfactory in treating a child (Fig. 268). Both the injured limb and the sound limb should be flexed to a right angle with the pelvis, fixed by light splints, and fastened to a bar above the bed. The weight of the body produces counter-extension and the child can be easily cleaned.*

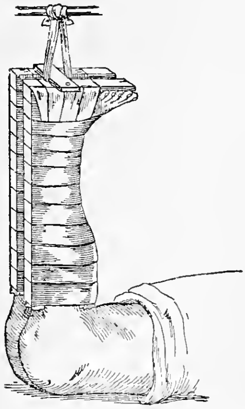


Fig. 268.—Bryant's extension for fracture of the thigh in a child.

Another plan is that of Theodore Dunham.† The child is placed upon a table, and the knee and thigh are partly flexed. After first applying flannel rollers, plaster-of-Paris bandages are applied from the roots of the toes to the spine of the tibia, and as a spica about the upper part of the thigh and pelvis. Two pieces of iron, suitably bent, are used to anchor the two plaster bandages together. One end of one iron is attached to the plaster over the groin and one end of the other iron is attached to the plaster over the front of the leg. The free ends of the irons overlap. At the points over the joints and the front of the leg where the irons are to rest masses of plaster are placed. The iron is sunk into the plaster and supported at each spot by several turns of a plaster bandage. While the irons are being adjusted the thigh is so held as to prevent bending or rotation, and the hip and knees are semiflexed. When the plaster has set an assistant makes extension on the leg and another assistant makes counter-extension by pressing on the pelvis. Any shortening is thus reduced and the two irons are lashed together with strong cord (Fig. 269).

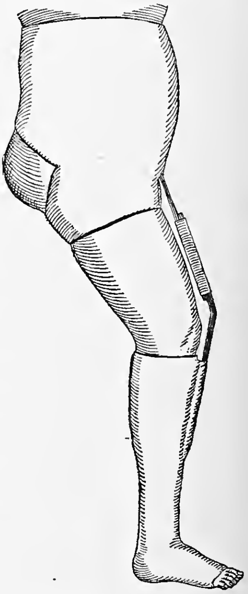


Fig. 269.—Dunham's apparatus for treating fractures of the thigh in infants and children.

Van Arsdale's triangular splint is a very useful appliance. It is made of binders' board. A. Ernest Gallant ‡ describes its preparation and application as follows: Measure the length of the sound thigh from the middle of the groin to the end of the femur. Draw upon cardboard an outline of a double spade (playing-card spade) (Fig. 270). Each of the four sections (*A*, *B*, *C*, *D*) must be equal to the length of the child's thigh, the flanged portions being equal to the widest part of the thigh. The figure is then cut out. The cardboard is moistened on one side and folded on the dotted line, section *A* being lapped over *D*, so as to form a triangle. It is fastened together by adhesive plaster. The thigh is flexed and the triangle is applied so that one flanged por-

* Thomas Bryant's "Practice of Surgery." † Phil. Med. Jour., April 23, 1898.
‡ Jour. Amer. Med. Assoc., Dec. 18, 1897.

tion embraces the thigh and the other flanged portion rests on the abdomen (Fig. 273). The triangle is fixed in position by bandages, figure-of-eight turns being made around the knee and around the thigh and body. Plaster or starch bandages are then applied to fix the splint firmly. The leg should be bandaged from the toe to the knee to prevent swelling (Fig. 273). This splint is worn for three weeks. A child wearing this splint can sit on a chair, nurse, play on the floor and crawl about, may sleep on either side, and the dressing is not soiled by the evacuations.

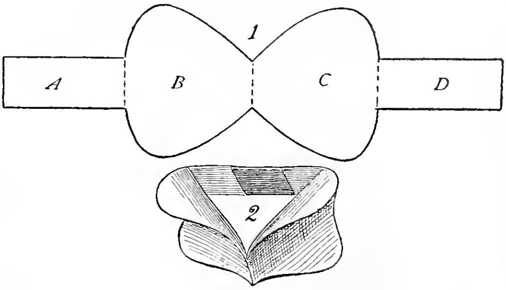


Fig. 270.—*1*, Diagram showing outline of Van Arsdale's splint; the end band to be folded on the dotted lines; each section to equal the length of the child's thigh. *2*, Diagram, splint folded, fastened by rubber plaster, flanges bent to embrace the thigh and abdomen, ready for adjustment (Gallant).

If a thigh is fractured during parturition, or during the first few weeks of life, Wyeth's dressing may be very serviceable. It is applied as follows: The leg is flexed on the thigh and the thigh on the abdomen. A flannel bandage is applied so as to include the leg, the thigh, and the body from the axilla to the pelvis. Plaster-of-Paris is applied over this; the dressing is worn for

Fig. 271.—Ware's combined pasteboard triangle and plaster-of-Paris spica apparatus for fracture of the femur in infancy (Ware, in "Annals of Surgery," August, 1905).

four weeks. A better dressing than the above is *Ware's, a modification* of *Van Arsdale's splint* ("Annals of Surg.," August, 1905) (Fig. 271). It is lighter, the patient can be moved about with ease, the child's toilet can be easily carried out, and breathing is not embarrassed. A right-angled triangle

Fig. 272.—Ware's apparatus for treatment of fracture of both femora (Ware, in "Annals of Surgery," August, 1905).

is made of bookbinders' board. The length of one side is the distance from the trunk at the level of the lower angle of the scapula to the inguinal fold. The length of the other side is the length of the thigh. The hypotenuse is, of course, longer than the sides. The cardboard is marked, bent into the tri-

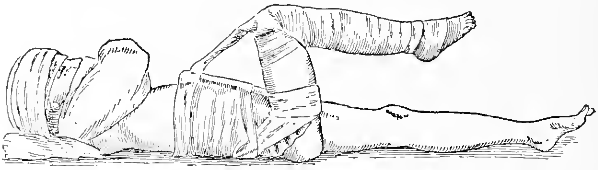


Fig. 273.—Showing Van Arsdale's triangular splint in position. Note the wide space between the dressings and the excretory passages (Gallant).

angle, and the overlapping edges are secured by means of adhesive plaster. The thigh is flexed and abducted, the inner surface of the splint is padded, the apparatus is applied and retained by a muslin spica about the trunk and thigh. Several turns of a dextrin bandage are applied over this to give strength. The

leg hangs free. The dressing is worn for three or four weeks. Fig. 271 shows this dressing applied for fracture of the right femur and Fig. 272 shows it applied when both bones are broken.

Fractures Just above the Condyles of the Femur.—The *line* of fracture above the condyles is well above the epiphyseal line. The femoral artery is in danger from the fragments. The *cause* of the break, as a rule, is direct violence. Indirect force is sometimes responsible (falls upon the feet). The knee-joint may be opened. The fracture is sometimes compound.

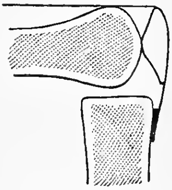


Fig. 274.—Mechanism of fracture of the patella by muscular action (after Treves).

Symptoms.—The upper end of the lower fragment is drawn upward and backward, because of the action of the rectus, hamstrings, gastrocnemius, and popliteus. The upper fragment passes inward, and the deformity is very manifest. There are shortening, crepitus, and mobility. The ends of the fragments can be felt by the surgeon. If the force has been very great, a T-fracture results. In T-fracture the knee is broadened and crepitus is obtained by moving the condyles, one up and the other down. Always feel for the pulse below the fracture.

Treatment.—In treating fracture above the condyles, reduce the deformity by horizontal extension. If this fails, make traction at the same time, gradually bringing the leg to a right angle with the thigh. Place the limb on a double inclined plane for five weeks, then begin passive motion once every other day, restoring the limb to the splint after the movements are completed. At the end of eight weeks after the accident remove the dressings, and, if the knee-joint be stiff, use for some time massage, passive motion, hot and cold douches, ichthyol inunctions, etc. Bryant treats this fracture in extension, cutting the tendo Achillis, if necessary, to amend deformity. It is occasionally necessary to wire the fragments. Some cases demand amputation because of injury to the structures in the popliteal space.

Fig. 275.—Fracture of the patella.

Fracture Separating Either Condyle.—The *cause* is direct force.

Symptoms and Treatment. — The broken piece is drawn upward, the leg bends toward the injury, crepitus exists, the knee is much broadened, there is no shortening, and considerable swelling is sure to arise. In treating a fracture separating either condyle, use a double inclined plane as directed above.

Longitudinal fractures run upward from the knee-joint. The *cause* is a fall upon the feet or the knees.

Symptoms and Treatment.—The symptoms of longitudinal fracture are often obscure. The femur is broadened when the knee is flexed. The split may be detected between the condyles. The *treatment* is the straight position in plaster for eight weeks.

Separation of the lower epiphysis occurs only before the twenty-first year. It is not a very rare accident in children.

Symptoms.—The symptoms in separation of the lower epiphysis are like those of transverse fracture, but crepitus is moist. The lower fragment is tilted, so that the articular surface looks forward. The lower end of the upper fragment projects into the popliteal space. There is danger to the structures in the popliteal space and that the growth of bone will be stunted. Feel for the pulse in the leg or foot.

Treatment.—Reduction may be effected in some cases by horizontal extension. Occasionally this is impossible.* In such a case adopt the plan of

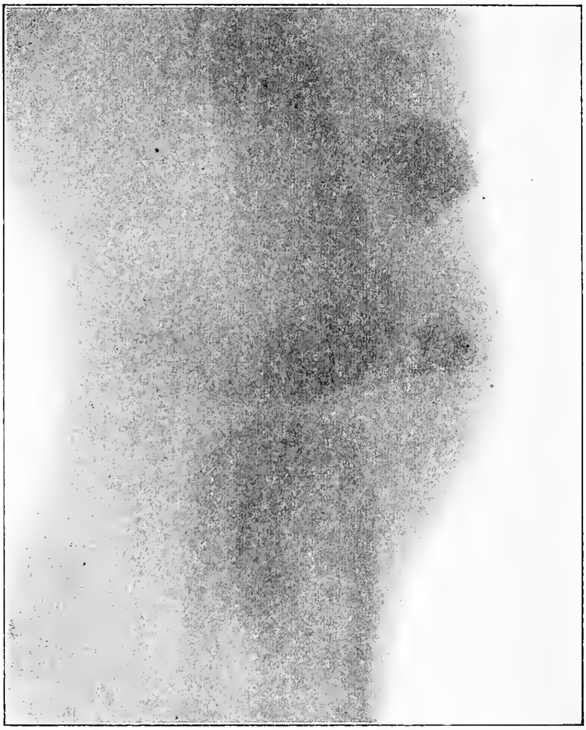


Fig. 276.—Fracture of the patella (Pennsylvania Hospital case; skiagraphed by Dr. Gaston Torrance).

Hutchinson and Barnard, make extension, and while it is being made gradually place the leg at a right angle to the thigh. This is effected by an assistant making traction on the leg, while the surgeon clasps his hands beneath the lower part of the thigh and draws upward. The treatment for separation of the lower epiphysis is the use of a double inclined plane as above directed. In some cases replacement is impossible without incision.

Fracture of the patella is a very common accident. The *cause* is direct force (producing vertical, star-shaped, or oblique lines of fracture) or muscular action (producing a transverse line of fracture).

* See the case reported by Jonathan Hutchinson, Jr., and Harold L. Barnard, Lancet, May 13, 1899.

Transverse Fractures of the Patella.—The knee-cap is more often broken by muscular action than is any other bone. When the knee is partly flexed the middle third of the patella rests upon the condyles of the femur and the upper third of the knee-cap projects above them; when in this position a contraction of the quadriceps may easily cause a fracture near the center of the bone (Fig. 274). The accident may be caused by sudden flexion of the knee when the quadriceps is contracting. The most usual cause is a fall or an attempt of the patient to save himself from a fall. Both patellæ may be broken at once. In fracture of the patella the joint, and often the prepatellar bursa, is opened. Fractures by muscular action are transverse. The

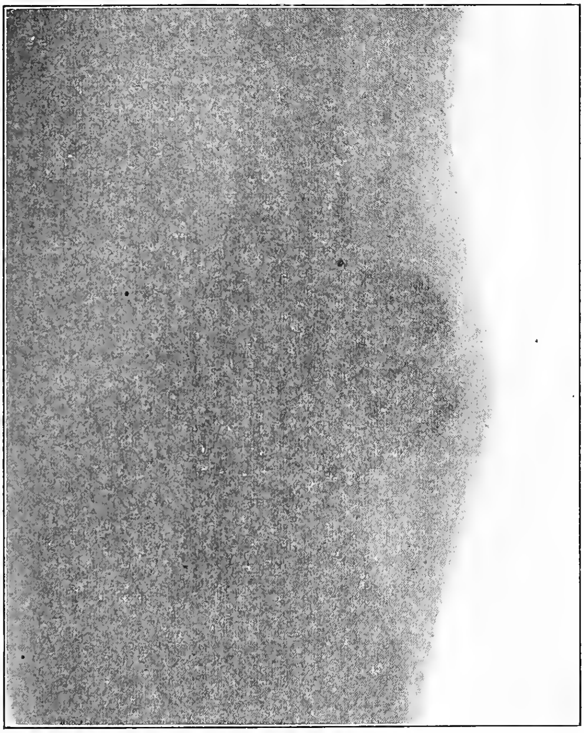


Fig. 277.—Fracture of the patella (Pennsylvania Hospital case; skiagraphed by Dr. Gaston Torrance).

injury is more common in males than in females, and is extremely rare in the very young and the old. It is an injury of active manhood and middle life.

Symptoms.—When the accident happens there is often an audible crack. As a rule, the patient will not try to use the limb, although it is possible for him to stand, to walk backward, and to move slowly forward when the extremity is kept straight. After the accident there is rapid and enormous swelling, due to the effusion first of blood and then of synovia and inflammatory products into and around the joint. The patient is absolutely unable to raise the limb from the bed. The fragments are movable and usually widely separated (Fig. 276), this separation being distinctly manifest to the touch

unless swelling is great. The separation is accentuated by flexion of the leg. The separation may be to the extent of one inch or even more. In cases in which the lateral fibrous expansions and periosteum are but slightly torn, there may be slight separation or no separation. Separation is due in part "to the retraction of the quadriceps and the tension of the fascia lata, and in part to distention of the joint by blood and exudate."* If fragments are not approximated and union does not occur, the separation becomes gradually greater because of the progressive shortening of the muscle and the retraction of the ligamentum patellæ (Stimson). In some cases an anterior angular displacement occurs because of the intra-articular distention (Fig. 277). It may be produced by the pressure of bandages or strips of plaster when the fragments have been brought together. Crepitus is detected if the upper fragment can be pushed down until it touches the lower piece; but if swelling is great, or if fibrous tissue is interposed between the bones, crepitus cannot be elicited. It is not necessary to obtain crepitus in order to make the diagnosis: the condition is obvious without this sign. The anterior fibroperiosteal layer is torn, and the tear does not correspond exactly with the line of fracture. A portion of this torn fibroperiosteal layer may, as Macewen pointed out, drop between the fragments and prevent union (Fig. 278). The lateral expansions of the capsule are usually extensively torn. If union occurs after a transverse fracture, it will probably be ligamentous, and if the patient gets about too soon, even apparently well-united fragments will by degrees stretch far asunder.

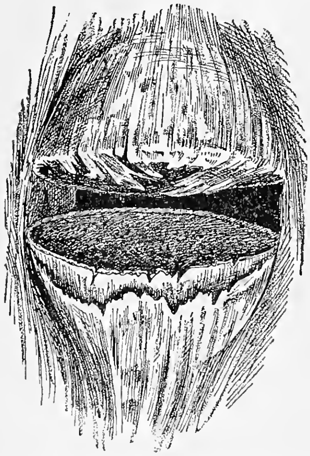


Fig. 278.—Transverse fracture of the patella; fractured surface partially covered by irregular flaps of torn aponeurosis (Hoffa).

Treatment of Transverse Fractures of the Patella.—The Conservative Plan.—If the swelling is so great as to prevent approximation of the fragments, reduce it by bandaging for a day or two, by using ice-bags, or by aspirating the joint. As a rule, the blood does not coagulate for several days. After it coagulates it cannot be withdrawn by aspiration, but only by incision. When the swelling diminishes, bring the two fragments into apposition, pull them together by adhesive plaster, and put on a well-padded

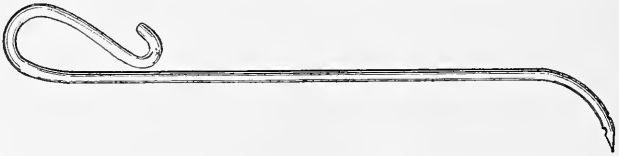


Fig. 279.—Needle specially designed to carry a thick wire. The eye is drilled obliquely, and should receive only a little loop on the end of the wire; this loop should be made previously.

*Stimson's "Treatise on Fractures and Dislocations."

posterior splint. Carry a piece of adhesive plaster over the upper end of the upper fragment, draw the bone down, and fasten the plaster to the splint behind and below the level of the joint. Carry another piece of plaster over the lower end of the fragment, draw the bone up, and fasten the plaster to the splint behind and above the joint. Carry a third piece over the junction of the fragments to prevent tilting. Agnew's splint admirably accomplishes this approximation (Pl. 6, Figs. 11, 12). A bandage holds the splint in place, and may be carried around the knee by figure-of-eight turns. The heel is sometimes raised upon a pillow so as to extend the leg and to semiflex the thigh, but this is not essential. Remove and reapply the dressing every few days, as it inevitably becomes loose. At the end of three weeks remove the splint permanently and apply a plaster-of-Paris dressing from just above the ankle to the middle of the thigh, and get the patient about on crutches. The dressing is to be worn for five weeks. After eight weeks of treatment allow the patient to walk with canes, the joint being kept fixed for four weeks more by pasteboard splints or by a light plaster-of-Paris bandage. For months after removing the splints and plaster a lacing knee-cap of leather should be worn in the daytime to support the joint. The plan of prolonged immobilization renders more or less joint-stiffness a certain occurrence, but this is less of an impediment than the wide separation of the fragments that inevitably attends an early use of the joint. Bryant, of New York, has devised an ambulatory dressing.

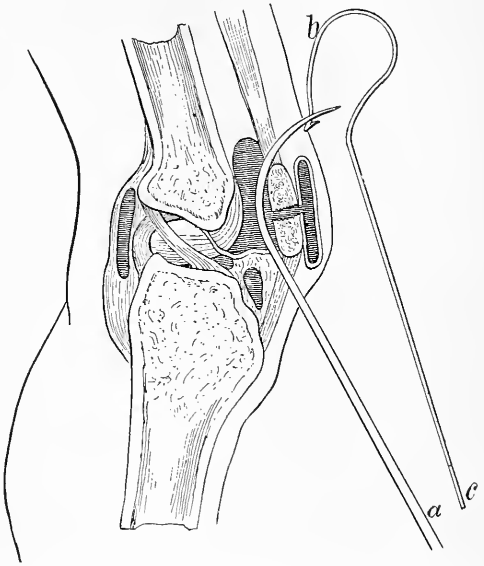


Fig. 280.—Needle (*a*) introduced behind the fragments, and receiving one end (*b*) of the silver wire (*b*, *c*) (Barker).

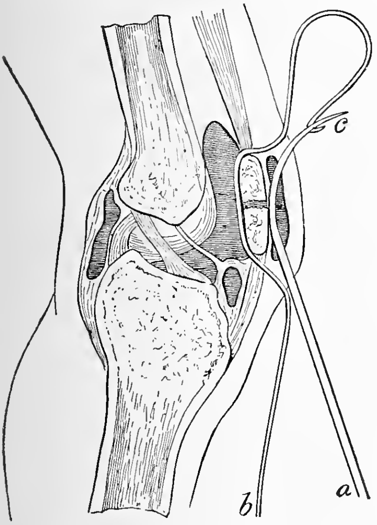


Fig. 281.—Needle (*a*) passed in front of the fragments and receiving the other end (*c*) of the silver wire (*b*, *c*) (Barker).

Operative Treatment.—Malgaigne's hooks are practically obsolete.

It is said that John Rhea Barton wired an ununited fracture of the patella in 1843. In 1877 Hector Cameron wired an ununited fracture of the patella,

and a few months later Lord Lister operated on a fracture of the knee-cap two weeks after the accident. The question of the advisability of suturing a recent fracture is very much disputed. The ordinary non-operative plans of treatment do not endanger life and generally give a good functional result. The operative method will usually succeed, and is capable of obtaining a better functional result and of obtaining it more rapidly. There is some danger of infection, and if infection should occur, the results will be most disastrous. Some cases obviously cannot be treated by the ordinary method with any chance of success; cases, for instance, in which a flap of fibroperiosteum intervenes between the fragments, or cases in which from some other cause the bones cannot be approximated. Such cases should, of course, be operated upon. But in the great majority of cases a good result will follow conservative treatment, and conservative treatment should be trusted to unless the case is in the hands of a surgeon and in a place where every antiseptic precaution can be taken. We agree with Stimson when he says that operative methods can be used with confidence when surrounded with every protection; he habitually uses them, but he never teaches them as proper routine practice, and strongly advises against their use except by those who have had experience in operating, who have formed the habit of taking precautions, and who have the aid of skilled assistants.* Operation should only be performed on healthy persons of suitable age, when the separation is over one-half an inch or when there is much laceration of the capsule.† Barker believes strongly in wiring recent transverse fractures. He does it with antiseptic care soon after the accident, and permits passive motion or even slight active motion immediately after the operation. Massage is begun the day after the operation, and is practised daily for two weeks.

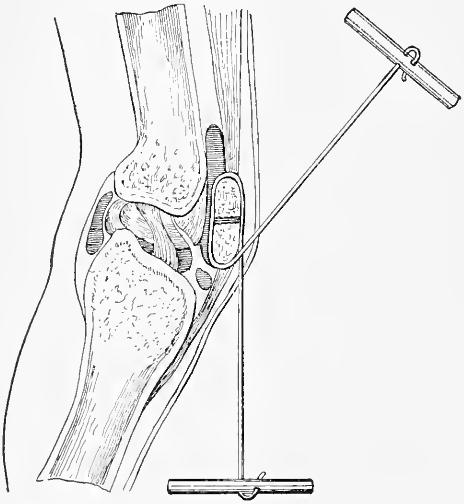


Fig. 282.—Wire in position round fragments and threaded through metal bars. The lower and posterior wire runs upward to the left of the upper, ready for twisting (Barker).

Barker ‡ uses a special needle (Fig. 279) and silver wire of the thickness of a No. 1 English catheter. This wire is straightened and softened in a spirit-flame. He rubs the bone fragments together in order to dislodge blood or fibrous material, and when marked grating occurs, introduces the wire. A puncture with a small knife is made through the middle of the upper attachment of the patellar ligament. The needle, not carrying any wire, is made to enter

* Annals of Surgery, Aug., 1898.

† Powers, in Annals of Surgery, July, 1898.

‡ See the objections of Sir William Stokes to Barker's method, in Brit. Med. Jour., Dec. 3, 1898.

through this opening into the joint, is passed back of the fragments, pierces the tendon of the quadriceps at the upper edge of the upper fragment, and its point is cut upon with a knife. The wire is inserted into the eye of the needle and the needle is withdrawn and unthreaded. The empty needle is pushed through the lower opening, is carried in front of the joint, is made to emerge at the upper opening, is threaded with the protruding wire and withdrawn (Figs. 280, 281). The wires are threaded into bars and twisted (Fig. 282), the ends are cut off, and antiseptic dressings are applied. There are objec-

Fig. 283.—Wired fracture of the patella (St. Joseph's Hospital case; operated upon and skiagraphed by Dr. Nassau).

tions to Barker's operation: It does not allow us to remove blood-clots from the joint; if a bit of tissue intervenes between the fragments, it cannot be removed; and a foreign body is left permanently in the joint.* If an operation is thought advisable, we deem it best to do an open operation, making a semilunar or a central longitudinal incision, freeing the joint from blood-clots by irrigation with hot salt solution, removing all tissue from between the fragments, drilling the fragments, passing silver wire, twisting the wire and drawing the fragments together, and closing the wound (Fig. 283). Instead

*Brit. Med. Jour., April 11, 1896.

of wire, silk may be used. In cases in which there is no very strong tendency to separation the fragments can be held together by several catgut sutures through the periosteum at the fractured edges or by a strong catgut suture passed through the ligamentum patellæ and the quadriceps tendon and carried in front of the fracture (Stimson). The limb should be placed on a posterior splint. In seven or eight days the superficial sutures are removed and a plaster-of-Paris splint is applied. In a few days the patient gets about on crutches. In a month the dressing is cut down the front and worn only in the daytime, and passive motion is begun. The splint is discarded at the end of the third month.* Among other operative procedures we may mention the following: Encircling the fragments with a silk suture (the circumferential suture). This suture may impair bone nutrition and retard union. Ceci drills the bones subcutaneously and passes wire through the drill-holes in the form of a figure-of-eight. Passing subcutaneously a ligature around and over the fragments (Butcher). Incision and approximation of the fragments by fixation-hooks or metal pins.

Fractures of the patella by direct force are vertical, stellate, oblique, or V-shaped, are often incomplete and occasionally compound or comminuted.

Symptoms.—Fractures of the patella by direct force are followed by discoloration, swelling, great difficulty in movement, and much pain. There may or may not be crepitus. The degree of separation of the fragments depends upon the direction of the line of fracture and the extent of bone involved. Bony union is apt to occur after such a fracture.

Treatment.—A fracture resulting from direct force may often be treated with a posterior splint and the application of a bandage. If there is any separation, the fragments should be approximated by adhesive strips, bandages, and compresses. At the end of three weeks remove the posterior splint, apply a plaster-of-Paris splint, and get the patient about on crutches. The danger in these cases is ankylosis rather than non-union; hence, in the fourth week, cut the plaster splint down the front and begin passive motion of the knee-joint. At the end of six weeks cease wearing the dressing in the daytime, and at the end of three months discard it entirely. In those rather unusual cases, in which an oblique fracture with wide separation arises from direct force, treat as advised for transverse fracture from muscular action. The question of operation is practically the same as for transverse fracture from muscular action. In every compound fracture of the patella, if amputation can be avoided, incise, irrigate the joint with hot saline fluid, suture the fragments, and drain for twenty-four to forty-eight hours.

Ununited and Badly United Fracture of the Patella.—There is usually a band of union, but it may be very thin and the fragments may be far asunder. It is commonly taught that the degree of functional impairment depends directly on the amount of separation. This is not strictly true. There may be great separation and but little impairment of function, the fragments being firmly united with a dense fibrous band. There may be little separation and yet lameness, stiffness of the joint, and imperfect power of extension. The reason for this has been pointed out by Bruns, of Tübingen.† He says there may be complete failure of union, even when the separation is trivial, and

*Stimson, Annals of Surgery, Aug., 1898.

† "Beiträge zur klinischen Chirurgie," "Mittheilungen aus der chirurg. Klinik zu Tübingen," Bd. iii, Heft 2, 1888.

failure of union produces impaired function. If separation is considerable, the fragments are apt to tilt and tissue is often interposed between them. Functional difficulty is more often met with when the fragments are far apart than when they are near together, because non-union is more common. Even if non-union occurs, in some cases the quadriceps is still able to act upon the tibia by means of the fascia lata, ligaments at the sides of the joint, or bands from the vasti to the lower fragment. Besides non-union, functional impairment may be due to anchoring of the upper fragment to the femur. The upper fragment is anchored to the femur by the interposition of the fibrous investment of the knee-cap, which covers the fractured surface of the upper fragment and grows fast to the capsule of the joint (Bruns).

The *treatment* of ununited and badly united fracture is discussed on page 466.

Fractures of the Leg.—In leg-fractures both bones or only one bone may be broken.

Fractures of the tibia are divided into (1) fractures of the upper end; (2) separation of the upper epiphysis; (3) fractures of the shaft; (4) fractures of the lower end; and (5) separation of the lower epiphysis.

Fractures of the upper end of the tibia are uncommon. They may be transverse, oblique, or vertical, running into the joint. The *cause* is direct violence.

Symptoms.—In fracture of the upper end of the tibia there is contusion of the soft parts. In a *transverse* fracture there are mobility and crepitus, but there is little displacement. In *oblique* fracture crepitus and mobility are marked, the axis of the limb is altered, and the fragment may be displaced. In fractures entering the joint there is great swelling of the knee-joint. In *comminuted* fractures, which exhibit marked signs, union is readily obtained, but if the joint has been damaged, stiffness is sure to ensue.

Treatment.—Reduce displacement by extension and manipulation. The special apparatus used depends on the case. In some cases extension is required, in some a posterior splint is applied and the limb is suspended from a gallows, in some a double inclined plane is employed, and in some a plaster-of-Paris splint is used.

The double inclined plane in the form of McIntyre's splint is frequently employed, or a double inclined plane in the form of a fracture-box may be preferred. The extremity should be immobilized for four weeks, when passive motion should be begun. Passive motion is to be made daily, the dressing being reapplied after each séance. In five or six weeks the dressings are removed and the patient allowed to go about on crutches. The crutches are soon abandoned for a cane, and later all support is dispensed with. If a fracture extends into the knee-joint and the ill-adjusted fragments block the articulation, the joint should be opened and the fragments placed in proper position.

Separation of the tubercle of the tibia is due to violent contraction of the quadriceps, and occurs only in those under twenty years of age. The fragment is drawn up and can be felt, and the patient is unable to use the limb. In a case in which the tibial spine has been torn off, the limb should be placed on a posterior straight splint and the fragment should be pulled down into place by adhesive strips and bandages. The splint should be worn for five weeks.

Separation of the Upper Epiphysis of the Tibia.—This is an injury of extreme rarity. It does not seem to occur after the sixteenth year. It is caused by a twist or by violent abduction or adduction of the leg. It may lead to lessened growth of the limb. The *treatment* is as for a fracture of the upper end.

Fractures of the Shaft of the Tibia.—The *causes* of these fractures are direct force, indirect force, or torsion. A fracture in the upper part of the bone is usually transverse; in the lower part it is usually oblique (T. Pickering Pick).

Symptoms.—In transverse fracture of the shaft of the tibia there is no deformity, and the support of the fibula may even permit of walking; there is fixed pain; there may or may not be inequality of the fragments felt by the finger; and there are crepitus, mobility, and often linear ecchymosis. In oblique fractures there usually exist crepitus, a little mobility, and distinct deformity. The deformity depends on the direction of the line of fracture, and, as this line is usually from above downward, inward, and a little forward, the lower fragment usually passes behind the upper fragment and rotates inward.

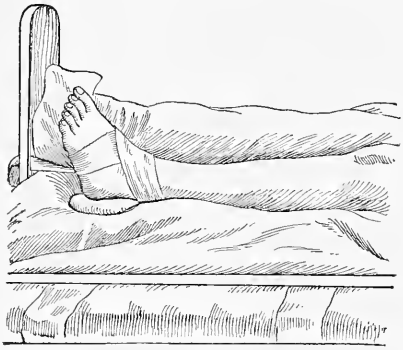


Fig. 284.—Fracture-box in fractures of the bones of the leg.

Treatment.—In treating fractures of the shaft of the tibia effect reduction by making extension from the foot and counter-extension from the knee, the knee-joint being in partial flexion. If there is much swelling, put the limb in a fracture-box (Fig. 284, and Pl. 6, Fig. 1), swing the box from a gallows, and apply an ice-bag for a day or two. A silicate of sodium or a plaster-of-Paris dressing is applied when the swelling subsides, or the dressing may be used at once instead of a fracture-box if swelling is slight. As soon as the limb is immobilized in a silicate or plaster dressing the patient gets about on crutches. The dressing is removed after five weeks, and the patient goes about for one week on crutches, lightly using the foot, and then for a time with a cane. At the end of eight or nine weeks the cane may often be dispensed with, the amount of use of the leg being daily augmented.

Fractures of the Lower End of the Tibia: Fracture of the Inner Malleolus.—The *cause* of fracture of the inner malleolus is direct force or traction upon the internal lateral ligament.

Symptoms and Treatment.—The *symptoms* of fracture of the inner malleolus are some downward displacement, depression above the ends of the fragments, mobility, and crepitus. The *treatment* is to push the fragments into place and use side-splints or a fracture-box for two weeks, when a plaster-of-Paris or a silicate dressing may be substituted and the patient be ordered to use crutches. Remove the plaster four or five weeks after it is applied, and direct the patient to gradually bear his weight upon the leg, as outlined above.

Separation of the lower epiphysis of the tibia is a rare accident, but

is commoner than separation of the upper epiphysis. The *treatment* is a fixed dressing for six weeks.

Fracture of the fibula alone is commoner by far than is fracture of the tibia alone. Fractures in the upper two-thirds, which are rare, are usually due to direct force. Fractures in the lower third are frequent, and arise from indirect force.

Fractures of the Upper Two-thirds of the Fibula.—In these fractures the *cause* is direct force.

Symptoms.—In fracture of the upper two-thirds of the fibula the patient is frequently able to walk. The bone is deeply situated, and displacement cannot often be detected. There is a fixed pain, which is intensified by movement and by pressure. Pressure upon the lower fragment does not move the upper fragment. Crepitus is sometimes obtained, and a linear ecchymosis is apt to appear. The bone is normally elastic, hence slight mobility is of no value diagnostically.

Treatment.—In treating a fracture of the upper two-thirds of the fibula apply a plaster-of-Paris or a silicate bandage and direct that it be worn for five weeks. Weight is not to be put upon the foot for six weeks after the accident.

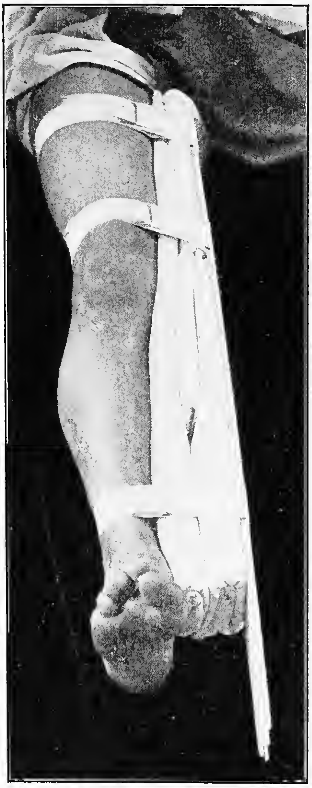


Fig. 285.—Pott's fracture. Dupuytren's splint. Note length of splint; position of straps; arrangement of padding; space between foot and splint (Scudder).

Fractures of the Lower Third of the Fibula.—In these fractures the *cause* is indirect force, especially twists of the foot. Forcible inversion of the foot pulls upon the external lateral ligament and the external malleolus, forces the fibula outward, and tends to break it, the lower fragment being displaced outward. Forcible eversion pulls the internal lateral ligament off from the inner malleolus (often breaks the malleolus) and fractures the fibula above the ankle, the bone being displaced inward.

Pott's Fracture.—By the term Pott's fracture is meant a fracture of the lower fifth of the fibula produced by eversion and abduction of the foot. Stimson points out that the production of Pott's fracture is often aided by the weight of the body. The lesions which arise depend upon whether the chief force is eversion or abduction. "If eversion is the sole, or main, movement, the force is exerted through the internal lateral ligament and breaks the internal malleolus squarely off at its base; then it presses the external malleolus outward, rupturing the tibiofibular ligament, and breaks the fibula close above the malleolus. Sometimes instead of pure rupture of the tibiofibular ligament there is avulsion of the portion of the tibia to which it is attached."* Stimson further points out that if abduction is the preponderat-

* "A Practical Treatise on Fractures and Dislocations," by Lewis A. Stimson.

ing force there is an oblique fracture of the anterior portion of the internal malleolus or more frequently rupture of the anterior portion of the internal lateral ligament. There are, as in the former case, rupture of the tibiofibular ligament and an oblique fracture of the fibula several inches above the external malleolus. It is evident that the degree of injury produced by eversion and abduction depends on the point at which the force is arrested. It may be arrested after the inner malleolus has been separated or the anterior fibers of the deltoid ligament torn, and in this case the tibiofibular articulation remains intact and the fibula is not broken. It may cease after separating the tibiofibular articulation, and in this case too the fibula escapes. It may be continued until the fibula breaks. In this fracture the astragalus passes outward, somewhat backward and also upward, the later deviation being due to separation of the tibiofibular articulation.

Symptoms.—The foot is displaced outward, and a little backward and upward, and the inner malleolus or the tibia from which it was torn is extremely prominent. There is great lateral mobility and often anteroposterior mobility at the ankle-joint. Stimson points out that there are three points where pressure is certain to provoke pain: in front of the tibiofibular ligament, at the base or anterior border of the inner malleolus, and over the seat of fracture through the fibula.

Treatment.—Thorough reduction is of the greatest importance. If thorough reduction is effected, a good result will probably be obtained; but if thorough reduction is not effected, the patient will be permanently crippled to a greater or less extent. In order to effect reduction it may be necessary to anesthetize the patient. The deformity is corrected "by pressing the calcaneum forward and inward; the hand is placed against the back and outer side of the heel and pressed forward and then forcibly inward." *

Some surgeons, at once after reduction, apply a plaster-of-Paris bandage. This treatment is objectionable because the deformity may be partially reproduced after the application of the dressing, the surgeon being unable to see it and unable to correct it.

If there seems to be no strong tendency to a recurrence of deformity, a fracture-box can be used. After reducing displacement in such a case, place the limb in a fracture-box containing a soft pillow. A bird's-nest pad of cotton or oakum is made for the heel (Fig. 284). A fillet around the ankle fastens the foot to the foot-piece of the box; a pad of oakum rests between the foot-piece and the sole. A compress is placed below the outer malleolus and another one above the inner malleolus. Close the sides of the box and tie them together with a bandage, and swing the box on a gallows. Every day let down the sides of the box and rub the leg, the ankle, and the foot with alcohol. In ten days apply a plaster-of-Paris bandage and let the patient get about on crutches. Remove the plaster at the end of the fifth week after the accident, and let the patient go about with crutches for one week and with a cane for a week longer.

I am accustomed to dress most cases of Pott's fracture with a *Dupuytren splint*. This is a straight splint (Fig. 285 and Pl. 6, Fig. 9) which reaches from the head of the tibia to below the sole of the foot. This splint is padded, and a pyramidal pad with the base down is laid upon the inner surface of

* Stimson's "Practical Treatise on Fractures and Dislocations."

the leg, above the inner malleolus, the splint being put upon the inner surface of the leg, over the pad. The splint is fastened as shown in Plate 6, Fig. 9, and Fig. 285. If the short splint shown in Plate 6 is used, the leg is semiflexed upon the thigh and is laid upon the outer surface on a pillow. After ten days apply the plaster-of-Paris bandage, which is to be worn as above directed. Bryant treats Pott's fracture with a posterior splint, two lateral splints, and a swing. Stimson uses a posterior and lateral splint of plaster-of-Paris. This splint does not slip, as may Dupuytren's dressing, and does not hide the seat of fracture from view as does complete encasement with plaster-of-Paris. It is a most useful dressing. The fracture may be *compound*, a portion of the inner malleolus or of the tibia projecting through the wound. If it is necessary to introduce through-and-through drainage, the foot must be placed and kept at a right angle to the leg. If a compound fracture exists, it may be possible to wire the malleolus in place. In a reported case the wire was passed through the joint and around the fragment, and the result was good.* It would be better in most cases to nail the fragment in place.

Fracture of both bones of the leg is a very common injury, is often compound, and is not unusually comminuted. Fractures by direct force, such as blows or kicks, are commonest in the upper half of the leg. Fractures by indirect force, as by falls, are commonest in the lower half of the leg. In fractures from indirect force the tibia breaks first, and then the fibula breaks at a higher level. The point of greatest liability to fracture from indirect force is the junction of the lower and middle thirds. Fractures of the leg are usually oblique, but they may be transverse if arising from direct force. Spiral, torsion, or V-shaped fractures and longitudinal breaks sometimes occur. In oblique fractures, as a rule, the line of fracture runs from behind, downward, inward, and a little forward.

Symptoms.—Fracture of both bones of the leg is easy of recognition. The fibular fracture is detected as before described. By running the finger along the crest of the tibia displacement will be found, except in transverse fractures, when it may not occur. The common displacement is for the lower fragment to ascend and pass behind the lower end of the upper fragment and to rotate a little outward, and for the upper fragment to project in front. The ascent of the lower fragment is due to the action of the gastrocnemius and soleus muscles. If the line of fracture is in a direction the reverse of that which is usual, the lower fragment ascends in front of the lower end of the upper fragment. In fracture of both bones of the leg there are marked mobility and crepitus, severe pain, and inability to walk. In fractures from direct force there is more or less damage to the soft parts. A fracture of the shaft of the tibia near the ankle is distinguished from a dislocation by the fact that the deformity is easily reduced, but tends to recur in the fracture, and, further, that in a fracture the relations of the malleoli to the tarsus are unaltered, whereas in a dislocation they are altered.

Treatment.—If the fracture is near the ankle-joint, the action of the tendo Achillis may maintain deformity, and in such cases the tendon should be divided. In treating a simple fracture of the lower two-thirds of the bones reduce by extension and counter-extension, and use a fracture-box

* Rev. de Chir., vol. viii, 1888.

(Fig. 284), though the compresses used in Pott's fracture are not required. If the soft parts are bruised, use an ice-bag for a day or two; if they are abraded, apply antiseptic dressings. The fracture-box should be swung upon a gallows. After three weeks apply a plaster-of-Paris or silicate of sodium dressing and let the patient sit up in a chair daily for one week; at the end of this time the patient may get about with crutches. At the end of six weeks after the accident remove the plaster, and let the sufferer go about on crutches for two weeks and with a cane for two weeks more. Brinton dresses a fracture of both bones of the leg for two weeks in a fracture-box, for two weeks in side-splints made of metal, and for two weeks in an immovable dressing, allowing the patient to get about on crutches as soon as the plaster is put on. Instead of the fracture-box, we may use a posterior splint, two lateral splints, and a swing. Nathan R. Smith's anterior splint is used by some in the treatment of fractures of the leg. Many surgeons apply plaster-of-Paris in the form of an ambulatory dressing. In this dressing a solid apparatus reaches to the lower third of the thigh and below the sole of the foot. When the patient walks the weight is transmitted to the thigh (Figs. 208 and 209). In fractures of the upper third of the leg the McIntyre splint or the double inclined plane is used. If the fracture is *compound*, asepticize thoroughly, make a counter-opening, insert a drainage-tube, dress with bichlorid gauze, apply a plaster bandage, and cut trap-doors over the openings of the tube (see Fig. 213), or dress with the bracketed splint and plaster-of-Paris (Fig. 214). Remove the tube, as a rule, in about forty-eight hours; but the patient's temperature is the guide, not time of retention.

Fractures of the bones of the foot are rather rare accidents, although not so unusual as we once thought, for the *x*-ray has taught us that a considerable number of supposed sprains are in reality fractures. Owing to the number of the bones and to the elasticity of their connections, the force of blows and falls is spread and dissipated. The bones most often broken are the astragalus and the os calcis. Fractures from direct force are often compound. The *cause* of fracture of either the scaphoid, the cuboid, or one of the cuneiform bones is direct force. Simple fractures of the os calcis and astragalus may arise from crushes or twists of the foot, but result, as a rule, from indirect force, such as falls. The calcaneum may be broken by a direct blow. In rare instances the os calcis has been broken by contraction of the great calf-muscles. Forcible dorsal flexion of the foot may fracture the neck of the astragalus (Eisendrath). Compound fractures may result from gunshot-wounds, crushes, and falls.

Symptoms.—The history of the nature of the accident is of great importance. In fracture of the os calcis there are severe pain, swelling, crepitus, mobility, often an apparent widening of the bone, and not unusually a loss of the arch of the foot (Pick). In some cases the posterior fragment is drawn up by the calf-muscles, and in other cases there is deformity. In fracture of the astragalus displacement may occur which resembles that of a dislocation. Crepitus may or may not be detected. It can be elicited, as a rule, by rotating the foot while the heel is firmly held. If crepitus cannot be detected, we are not certain that a fracture is present, even though the patient may be unable to stand and there are swelling and pain on pressure. The malleoli may seem on a lower level than normal if the astragalus and

os calcis have been crushed. Sometimes the foot is shortened, and perhaps the fragments have been dislocated (Eisendrath, in "Annals of Surg.," March, 1905). The *x*-rays will make the diagnosis certain. Fractures of the other bones are difficult of detection except by the *x*-rays. There may or may not be crepitus, which, if it exists, is hard to localize; there is pain on standing and on pressure, and there is bruising of the soft parts.

Treatment.—In simple fracture of the os calcis and astragalus without displacement place the foot at a right angle to the leg and apply a plaster cast. This is cut down the front so that it may be removed easily. On the third or fourth day follow Eisendrath's advice and begin massage to reduce swelling and prevent muscular atrophy ("Annals of Surg.," March, 1905). The cast is worn for eight weeks, when the patient may begin to put weight upon the extremity. If a flat foot has resulted from the accident, a support must be worn (page 664). If there is displacement in a simple fracture of the os calcis or astragalus it is wisest to operate. Perfect correction is not possible otherwise and no apparatus is satisfactory. The fragments are restored after incision and may be nailed or wired in place. A fragment may require removal or the badly splintered bone itself may have to come away. If the tendo Achillis is torn loose, it should be sutured to the os calcis (Eisendrath). Fractures of the other bones of the tarsus are almost always compound, and the injury may require drainage and immovable dressing, excision of bones, or even amputation. If they are not compound, they may be treated by a plaster-of-Paris dressing or may require incision and fixation or removal.

Fractures of the metatarsal bones are almost invariably due to direct force and are almost always compound. Robert Jones has published skiagraphs of a fracture of the fifth metacarpal bone from indirect force. Crepitus may be absent because of impaction or fixation by interosseous ligaments. Jones says such a fracture may be produced by the pressure of the body-weight on an inverted foot the heel of which is raised ("Annals of Surgery," June, 1902). When only one bone is broken, displacement is slight, there is severe pain on motion and pressure, and crepitus can generally be obtained. Pain is produced by flexing the toes, putting weight upon the toes, as in walking, and by inverting or everting the foot. A simple fracture of a metatarsal bone is treated by an immovable dressing for four weeks. Fractures from crushes usually demand excision or amputation.

Fractures of the phalanges of the toes are due to direct force and are often compound. They may require immediate amputation.

Treatment.—In a compound fracture where amputation is unnecessary, drain with strands of catgut for forty-eight hours and dress antiseptically, at the end of this time apply over the bichlorid gauze a gutta-percha or a pasteboard splint extending from beyond the end of the toe to well up upon the sole of the foot, and fix the splint in place with a spiral bandage of the toe and instep. The splint is to be worn for four weeks. In a simple fracture fasten the injured toe to an adjacent toe or toes by a plaster bandage and wear the dressing for three weeks.

Diseases of the Joints.

Synovitis is a primary inflammation of the synovial membrane alone. If other structures besides the synovial membrane are involved, the condition is known as "arthritis." Two forms of simple synovitis exist—namely, *acute* and *chronic*. Some surgeons speak also of *subacute* cases.

Acute Simple Synovitis.—The *causes* of acute simple synovitis are contusions, sprains, twists, and overuse. The causative influence of exposure to cold or damp has been much debated. It seems probable that in some cases cold produces vasomotor paresis of the vessels of the synovial membrane, a condition which may be followed by inflammation. In synovitis the synovial membrane is red and swollen, and the joint contains an excess of turbid fibrinous fluid. If the inflammation advances, arthritis arises and sometimes blood is effused.

Symptoms.—A prominent symptom of acute synovitis is pain, which is increased by motion of the joint, by pressure upon the articulation, and by a dependent position of the limb, and which is worse at night. Pressure upon the cartilage does not cause pain, but friction of the synovial membrane at once develops it. The patient places the limb in the position which gives the greatest ease, and the part becomes more or less fixed in this position because the muscles about the joint are rigid. A fluctuating swelling is noted in a superficial joint, most marked between the ligaments, which swelling bulges out the synovial area and hides or obscures the articular heads of the bones. The swelling is due early to excessive secretion of synovia, and later to effusion of liquor sanguinis. Bulging takes place at points where the capsule is thin, and at such points fluctuation may be detected. Fluctuation in the elbow is sought for posteriorly. Fluctuation in the knee is sought for on either side in front. A large effusion in the knee floats the patella up from the condyles (*floating patella*). A small effusion in the knee can be detected by Fiske's plan, which is as follows: Tell the patient to bend forward at the hips, resting each hand on the front of the corresponding thigh. The anterior structures of the joint are thus relaxed, and, by tapping the patella, even a small effusion can be discovered. Bulging cannot be distinctly recognized in the hip or shoulder, unless effusion is great. The skin over the joint is rarely reddened, but feels hot to the hand of the observer (over superficial joints, but not over the shoulder and hip); the joint is partly flexed; fever exists, varying in degree with the size of the joint, the acuteness of the attack, and the nature of the cause. Suppuration rarely follows simple synovitis, but it may do so, the area of synovitis being a point of least resistance to organisms carried by the blood or lymph. If suppuration takes place, rigors occur, there is a septic temperature, and the joint soon gives evidences of containing pus. These evidences are violent pain, increased tenderness, dusky discoloration if the joint be superficial, greater muscular spasm, periarticular edema, and constitutional symptoms of sepsis. Traumatic synovitis without infection tends toward cure without suppuration if the patient is healthy, and after it ankylosis is rare.

Treatment.—In treating acute synovitis immobilize the joint. In severe cases place it in such a position that the limb will still be useful even if anky-

losis occurs. In mild cases immobilize in the position of rest, apply leeches, and use the ice-bag or the Leiter coil. After a day or two apply gentle pressure, intermittent heat, and iodin and ichthyol. If the effusion is very great and persistent, and pressure, heat, and sorbefacients fail to remove it, aspirate with aseptic care. If effusion recurs after aspiration, apply plaster-of Paris dressing or use flying blisters and massage. A rubber bandage is often useful toward the termination of a case.

Chronic Synovitis.—Chronic synovitis follows acute synovitis or it may be chronic from the start. Many cases called chronic synovitis are in truth tuberculous disease. The synovial membrane looks nearly natural, but is edematous, and the joint contains an excess of fluid. If the quantity of fluid is large, the disease is called "*hydrops articuli,*" or "*dropsy.*" A large amount of fluid in the knee-joint "floats" the patella upward. Tuberculous infection is apt to occur in very prolonged cases. In prolonged chronic synovitis the synovial membrane thickens in some places, softens in others, is often adherent, and the villous processes hypertrophy. If the membrane becomes extensively softened (*pulpy degeneration*), the softened areas bulge and caseation eventually occurs. In the knee-joint a traumatic synovitis is sometimes linked with *inflammation of the semilunar cartilages.* Roux tells us that this inflammation may be produced by a squeeze, a twist, or a direct force, but a squeeze is the common cause. Hyperextension of the knee may squeeze the cartilage, and so may attempting to rise from a stooping posture.* If this injury has taken place, the disability will be prolonged.

Symptoms.—In chronic synovitis pain is absent or is only present during exercise or from pressure, and is slight even then; there is some limitation of movement; passive motion may develop creaking or joint-crepitus; fluctuation is apparent and there is atrophy in the muscle about the joint. The atrophy of the muscles associated with an inflamed joint is a reflex atrophy and is named after Charcot. The hypodermatic needle will draw out a viscid, straw-colored or bloody fluid.

Treatment.—Rest and pressure are of great service. Pressure may be obtained by the application of Martin's rubber bandage. A plaster-of-Paris dressing is probably the best way to combine rest and compression. Massage, douches, frictions, passive movements, and flying blisters should be used. Painting the joint with iodin and spreading over it blue ointment, and rubbing in ointment of ichthyol (50 per cent. with lanolin) may do good. Counter-irritation by the actual cautery is a valuable expedient. Chronic synovitis is often greatly benefited by the use of a hot-air apparatus. The limb is wrapped in flannel and is placed in an oven. The oven is heated by Bunsen burners. The temperature is raised to about 300° F., and the limb is subjected to this for one hour. The oven should be used daily, and as the patient becomes accustomed to it even a higher degree of heat can be tolerated. This high degree of heat can be borne only when it is perfectly dry. Any moisture scalds the patient. The Lentz oven has in it ventilation openings to get rid of moisture and the sweat is taken up by the flannel. This flannel must not be applied so thickly as to keep the heat notably from the joint nor must so little of it be used as to permit of its soaking with sweat. Fig. 286 shows the Sprague hot dry-air apparatus, and Fig. 287 exhibits a

* Gaz. des Hôp., No. 125, 1895.

cross-section of the same apparatus. Dr. H. A. Wilson inserts in the oven humidin, a product obtained in the purification of salt, which material entirely absorbs the moisture. Cotton should not be used to wrap the limb, because, if the bottom of the oven becomes red-hot, the cotton may ignite and burn the patient. A physician or nurse should constantly watch the apparatus during its employment.* Aspiration and the subsequent use of a plaster-of-Paris bandage may be tried in some cases of chronic synovitis. Some surgeons advise aspiration, washing out with salt solution, injecting a 5 per cent. solution of carbolic acid, and immobilizing. Incision and drainage constitute a radical but proper plan in cases unamended by simpler methods. If pulpy

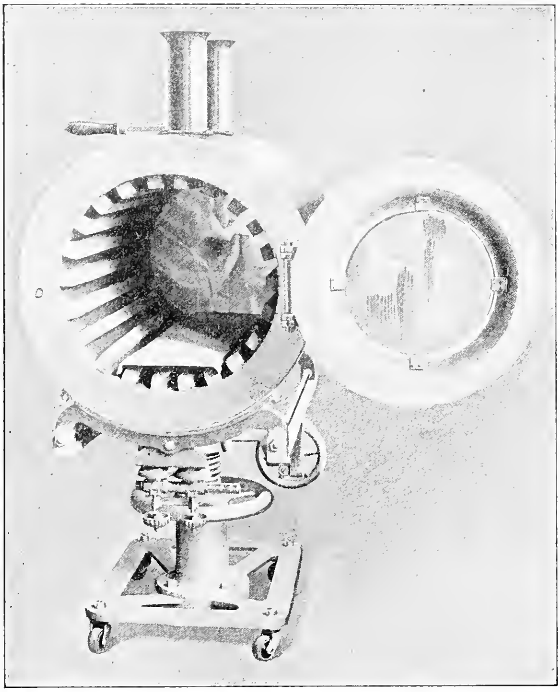


Fig. 286.—Sprague hot dry-air apparatus.

degeneration exists, perform an excision or an erasion. If pus forms, incise at once and drain. Internally, treat any existing diathesis and give nutritious food, tonics, and stimulants.

Arthritis.—By this term is meant not only inflammation of a synovial membrane, but also of other structures composing and surrounding a joint. It may follow traumatic synovitis; it may be due to pus-organisms, to tubercle bacilli, to infectious diseases (gonorrhea and typhoid fever), to rheumatism, to gout, to syphilis, and to lesions of the spinal cord. Arthritis may be either acute or chronic.

Tuberculous Arthritis (*White Swelling; Strumous Joint; Pulpy Degeneration*).—*Pathology and Symptoms.*—The predisposing causes of tubercu-

* H. A. Wilson, in Annals of Surgery, Feb., 1899.

lous arthritis may be strains, blows, twists, or cold. The real cause is the tubercle bacillus. A single joint is attacked. Other joints may subsequently become involved so that several suffer simultaneously, but it is rare that the process is active in more than one joint at the same time. During the course of tuberculous disease of a joint (except of the shoulder-joint) phthisis is not common, although it not unusually develops after the joint gets well. The same is true of tuberculous glands. During the existence of phthisis or tuberculous glands tuberculous arthritis does not frequently arise. The primary infection with tubercle bacilli is usually in the bone, though it may be in the synovial membrane, the joint-capsule, or the structures about the joint. The frequency of the bony origin of tuberculous arthritis is shown by Murphy's statement that in 128 cases of tuberculosis of the knee it was demonstrated in all but 2 that the condition originated in the bone (John B. Murphy, in "Jour. Am. Med. Assoc.," May 20–27, June 3, 1905). If the primary infective focus is in the bone, a portion of the cartilage is destroyed and the joint is opened, or a sinus forms and perforates the synovial membrane. When tuberculous inflammation attacks the synovial membrane granulation tissue is formed, and the capsule and periarticular structures soon become involved in the process; the parts thicken and soften from caseation, and they may be covered with tubercles, though but little fluid is usually effused into the joint. Some few cases present large joint effusions, but in most cases fluctuation is absent. Capsular thickening may or may not be manifest. Soon after tuberculous arthritis begins the joint becomes rigid, irritation having induced muscular spasm. This reflex rigidity fixes the joint more or less completely, and atrophy of the rigid muscles soon begins. There is usually pain in tuberculous arthritis, but it may be referred to a distant part. For instance, in hip-joint disease the pain is often referred to the inner side of the knee, and in Pott's disease of the spine the pain may be referred to the abdomen. Attempts at motion demonstrate the limitation of movement due to muscular rigidity and also produce pain. A child that suffers from a tuberculous joint is apt to be restless in sleep, moaning and tossing, and to wake at times crying out in terror (*night-cries* and *night-terrors*). In the ordinary form of tuberculous arthritis there occurs what is known as "*gelatiniform degeneration*"; the granulation tissue is formed in

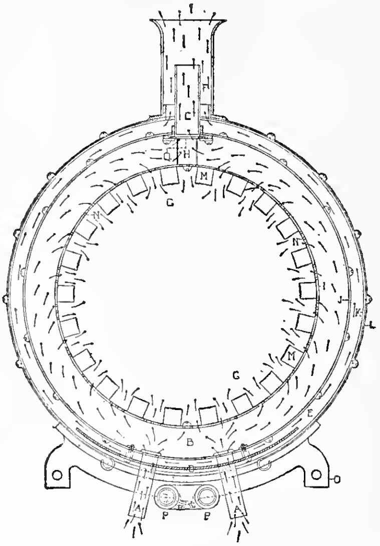


Fig. 287.—Cross-section of Sprague hot dry-air apparatus: A, A, Air intakes; B, circulating air space; E, jacketed space for products of combustion; G, treatment chamber; M, M, cork ribs; N, N, perforations admitting heated air; O, base holding apparatus; P, P, gas-burners.

large amount as fungous growths; the structures are markedly edematous and softened; the relaxed ligaments yield under pressure; the natural contour of the joint is lost, and it becomes spindle-shaped; all the structures, articular and periarticular, are glued into one mass; the skin about the joint is white, thick, and adherent, and in it one or more large veins are seen; fluctuation or pseudo-fluctuation is noted when caseation has occurred; pain is not often severe, but it can usually be elicited by certain motions or by firm pressure, but the pain will always be severe when the epiphysis is involved; the temperature of the part is seldom elevated; deformity results from destruction of bone, cartilage, and ligament, from muscular spasms, and from the habitual assumption of certain attitudes to secure relief from pain. There is soon impairment of joint-motions. When the products of a tuberculous arthritis caseate, the thick liquid seeks exit by forming sinuses from which caseous pus flows. If a sinus becomes infected with pyogenic cocci, and the joint itself becomes their prey, acute suppuration arises in the joint, and constitutional involvement is pronounced and perilous to life.

In *pannous synovitis* a large effusion is formed, there is but little granulation tissue, though the tubercles are present in large numbers, and the ligaments and structures about the joint are slightly or not at all implicated.

Diagnosis and Prognosis.—Tuberculous chronic synovitis produces great swelling and distinct thickening of the capsule with obliteration of the outlines of the joint, but there are no spasm, no atrophy, no limitation of motion, no severe pain, and no tendency to subluxation (Shaffer). Tuberculous arthritis rarely causes distinct fluctuation, does not thicken the capsule, causes reflex muscular spasm, rigidity of the joint, muscular atrophy, severe pain on movement, and eventually subluxation (Shaffer). In syphilitic arthritis there is usually some fluctuation, distinct enlargement of the joint, limitation of motion, no reflex spasm, trivial atrophy, but distinct pain on motion (James K. Young, "Therapeutic Gazette," June 15, 1902). Acute rheumatism attacks more than one joint, is very rare in childhood, and produces high fever. The *x*-rays aid in the diagnosis of tuberculous arthritis and enable us to tell the extent of bone-involvement.

The diagnosis in a tuberculous joint is often difficult, and sometimes impossible, and the prognosis is always grave. In only a very few cases, even when recognized early, is a cure obtained without some impairment of joint-function. The best that can usually be accomplished is a cure with more or less ankylosis, fibrous or bony; and often ankylosis is complete. Long after the disease is apparently cured, it may break forth anew. Tuberculous lesions may arise in a distant organ, or general tuberculosis may occur. Caseation is apt to produce severe constitutional disorder. Infection by pus-organisms gives rise to grave danger of septicemia. Death is not unusual from exhaustion, from septicemia, from disseminated tuberculosis, from tuberculosis of an important organ, or from amyloid disease.

Treatment.—Conservative treatment is especially successful in children. According to Hoffa, in 75 per cent. of cases in children non-operative treatment will produce cure ("Die Bekampfung der Knochen- u. Gelenktuberculose

in Kindesalter Tuberculosis," iv, 1, 1905). This conservative treatment consists in open-air life, if possible in a sanitarium, the following of the plans outlined under Tuberculosis, immobilization and extension of the joint, and injections of iodoform emulsion. Even when tuberculous pus forms the same treatment may be followed unless there is violent pain or elevated temperature which does not quickly abate, in which case operation must be performed. Cases treated early by conservative methods may get well with a movable joint, but in most cases there is a stiff joint when the disease is arrested. Constitutionally, the treatment is directed against the tuberculous diathesis. The patient should be placed under good hygienic conditions. A change of climate is often of the greatest importance. Many cases do well at the seaside; others require high altitudes, and all should live in the open air. Locally, rest is of the first importance, and it is maintained for many weeks. Rest is best secured by immobilization and traction, and traction is applied or maintained by splints, by plaster-of-Paris bandages, or by extension appliances. The hot-air apparatus may be of some benefit. If it is employed, it should be used daily, the limb being immobilized during the remainder of the twenty-four hours. Bier's plan of inducing congestive hyperemia is often of great service (page 228). Aspiration can be used for fluid accumulations. Caseous masses are often let alone, or an aspirator is used and the joint drained, washed out with saline solution, and injected with an emulsion of iodoform and glycerin (10 per cent.). From 1 to 2 drams are injected into the joint of a child, from 2 to 5 drams into the joint of an adult. This treatment is more serviceable in tuberculosis of the small joints than in disease of the large articulations. Injections of balsam of Peru or of iodoform emulsion about the joint once a week are efficient in some cases. If these means fail, if the patient gets worse, if there is persistent fever or violent pain, or if the condition of the sufferer renders dangerous the prolonged conservative course, operate, removing the entire diseased area by erasion, by excision, or possibly by amputation. If the *x*-ray picture shows extensive sequestrum formation, operation is indicated. If amyloid degeneration exists, conservative treatment is contraindicated and so is resection. Amputation must be done. Always remember that an incomplete operation or a partial removal, unless it consists of simple drainage, is worse than no operation, as it opens the portals to systemic infection, and may be responsible for the development of general tuberculosis, septicemia, or pyemia. Simple drainage, as previously stated, is seldom advisable. Garre is of the opinion that the hip, wrist, and shoulder do best by conservative treatment; the knee, elbow, and ankle by operative treatment (John W. Churchman, in "Am. Medicine," April, 1906).

Tuberculosis of Special Joints.—Tuberculosis of the Sacro-iliac Joint (*Sacro-iliac Disease*).—This is an uncommon affection, and is especially rare before the age of fifteen. The disease may begin in the joint, may arise in adjacent bones, or may result from a cold abscess burrowing into the joint. In some cases it is associated with extensive disease of the pelvic bones. The disease, if undetected, may lead to dissemination of tubercle, to abscess, or even to death.

Symptoms are often obscure. The disease is frequently confounded with vertebral caries, hip-joint disease, or sciatica. The patient limps on walking,

but can stand on either leg; there is pain in the sacro-iliac joint, about the hip, and down the thigh; tenderness is manifest on pressure over the joint and on pushing the ilia together; there is fulness over the sacro-iliac joint; but the hip is not flexed unless iliac abscess exists.*

Treatment.—Rest in bed for months, using also a felt case for the pelvis. Counter-irritation by blisters and the actual cautery. In some cases injection of iodoform; in others, incision and curetting. I have operated on six cases, with one death. In one case in the Jefferson Medical College Hospital the abscess was pointing in both the back and groin. Both areas were incised, the diseased bone was removed, and the boy ultimately recovered (Fig. 288). In another case the abscess pointed in the groin. The treatment was as previously set forth, and the patient, a woman, recovered.

Tuberculosis of the Hip-joint (*Hip Disease; Morbus Coxarius; Morbus Coxæ; Coxitis; Hip-joint Disease*).—The primary lesion may be in the

Fig. 288.—Sacro-iliac disease; operated upon and cured.

synovial membrane, but it is more often in the bone. It may begin in the acetabulum; it may begin in the femur. In 95 per cent. of cases it begins in the head of the femur. If it begins in the femur, it usually arises on "the distal side of the epiphyseal cartilage" (Senn). Sometimes primary tuberculosis arises in the trochanter major, and never involves the joint. When the synovial membrane becomes involved at any point, spreading throughout the joint is rapid. In many cases the articular cartilages are attacked, and in some cases the epiphyseal cartilage is destroyed. It is commonest in children, but it may arise in adults and even occasionally in those of advanced years; 62 per cent. of cases arise in children under ten years of age and 80 per cent. of cases occur before the twentieth year (Bryant). Traumatism and cold may be predisposing causes. The disease strongly tends to caseation and the formation of sequestra.

*See A. G. Miller, Edinburgh Med. Jour., May, 1895.

Symptoms.—It has been usual to divide the disease into three stages: (1) the stage of microbic deposition and multiplication, the products of the bacilli causing irritation and new growth; (2) the stage of progression, with formation of masses of granulation tissue and effusion into the joint; and (3) the stage of caseation, with destruction of the joint and often of the structures about it. Bradford and Lovett* protest against this. They say: "It has been customary to divide hip-disease into stages, and to ascribe to these stages certain definite symptoms. Neither from a clinical nor a pathological point of view is it desirable to attempt such a division." As H. Augustus Wilson says: "Tuberculous bone and joint disease should be considered as the primary invasion or incipiency, and all other symptoms should be regarded as results and not as an integral and necessary part of the trouble."

The symptoms of incipient coxalgia are slight and may be overlooked entirely. In a child there are night-terrors; on getting about in the morning the child shows no lameness, but a limp develops during the day, and the little one soon grows tired while playing and lies down to rest. There is a slight limp; some adductor spasm is noted, and pain may be complained of at night in the hip, in the front of the thigh, or at the inside of the knee. Tapping the sole of the foot, the thigh and leg being extended, may develop pain, just as it will develop pain in any inflammatory involvement of the joint. But the employment of this method is objectionable. It may injure a joint already damaged by the tuberculous process, and it gives no information which cannot be obtained by a safer mode of investigation. After all, pain on tapping the sole of the foot means only what muscular rigidity means, and muscular rigidity is always present and is easily demonstrable by careful manipulation. The diagnosis in this stage is more or less problematical.

As the disease progresses more positive symptoms are observed. The limp grows worse; the adductor muscles become rigid; the hip is broadened by an effusion into the joint, and fluctuation may possibly be detected; the thigh-muscles atrophy; the extremity is pushed forward, abducted, and everted (the patient tilts the pelvis so as to rest his weight on the sound limb). In some few cases adduction exists rather than abduction. The abduction, which is usual, releases tension of the fascia lata, and thus abolishes pressure upon the joint through lessening of pressure upon the great trochanter (Allis). The thigh is somewhat flexed. This flexion relaxes the psoas muscle and prevents pressure of its tendon upon the front of the joint (Allis). Pain exists, often sudden or starting, and is located in the joint, on the front of the thigh, and to the inner side of the knee in the course of the obturator nerve; the pain is aggravated at night; and full extension and complete abduction are not possible. The gluteal muscles waste, and the gluteal crease is on a lower level than is that of the sound side. The gluteal crease may be nearly or quite effaced, because of hypertrophy of the subcutaneous layer (Alexandroff). Jarring of the heel when the extremity is in extension causes pain in the hip. The above symptoms arise chiefly from unconscious efforts to obtain ease, from joint-effusion, reflex irritation, and involuntary or spasmodic muscular contractions. There is an appearance of lengthening, or shortening, but it is only apparent, not real. The real position is shown on Plate 7, Fig. 4. The fluid effusion may be absorbed or may find its way

* Orthopedic Surgery.

externally by means of sinuses. The latter condition is known as "*abscess of the hip*." The absorption of the exudate or the rupture of the capsule permits the contracting muscles to bring the head of the femur into firm contact with the acetabulum or its brim; the bones are worn away and destroyed, shortening results, abduction gives way to adduction, and flexion is increased, as shortening occurs.

In advanced cases of coxalgia the head of the femur passes upward and outward upon the rim of the acetabulum, the thigh is flexed and fixed, and attempts at extension when the patient is recumbent cause the pelvis to tilt forward and occasion a marked lumbar curve (lordosis) (Pl. 7, Fig. 2), which is due to the pelvis moving with the femur as if ankylosed, and which disappears on flexion. In this condition adduction occurs because of the ascent and movement outward of the head of the bone. Shortening is marked. After a hip-abscess finds an external outlet pyogenic infection is very apt to take place and suppuration arises, which is followed by that state which is designated as "hectic." If a cure follows advanced coxalgia, partial or complete anky-

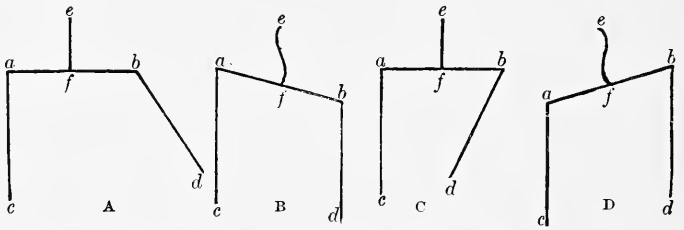


Fig. 289.—Positions in hip-joint disease (after the plan of Howard Marsh and Treves): A.—*e f*, lumbar spine; *b d*, limb fixed in flexion and abduction—useless for walking. B.—*e f*, lumbar spine. Patient corrects the condition in Figure A by curving the lumbar spine forward and rotating the pelvis on its transverse axis, thus making the femur point downward. The lumbar spine is curved laterally, the pelvis ascending on the sound side and descending on the affected side (apparent lengthening). C.—*b d*, limb fixed in flexion and adduction. D.—*e f*, curve of lumbar spine to correct condition in Figure C (apparent shortening).

losis takes place; if death ensues, it may be due to septicemia, tuberculosis of the viscera, exhaustion, or amyloid degeneration.

Diagnosis is very easy in well-established cases of hip-disease, but very difficult when the disease is incipient. Always make a systematic and thorough examination. Undress the patient and place him recumbent with his legs extended upon a table or a hard mattress. Note if the heels are level and if the iliac spines are on the same level (a depressed spine on the affected side means abducted extremity, the degree of which is determined by carrying the limb out until the spines are horizontal; elevation of the iliac spine on the affected side means adduction, the amount of which is determined by adducting the limb until the spines are horizontal; Fig. 289). Try all the movements belonging to the joint, to detect any limitations; observe if bringing down the knee produces lordosis; look for swelling and for muscular wasting; feel if the head of the bone is enlarged; determine if motion produces pain or if pressure develops tenderness; and always carefully elicit the history of the attack, of the person, and of the family.

Hip disease may be confounded with spinal caries in which a psoas or a

lumbar abscess has formed, with sacro-iliac disease, with infantile paralysis, with congenital dislocation of hip, with lordosis from rickets, with gluteal abscess, and with bursitis of the gluteal bursæ. In hip disease there is always some lameness; pain may be severe, may be trivial, or may be absent entirely, and may be in the hip or be referred to the front of the thigh or the inner side of the knee. Always remember that the pain is not characteristic, and that pain in the same localities may arise from aneurysm of the femoral or iliac arteries, from abscess in Scarpa's triangle, from caries of the lumbar vertebræ, from sacro-iliac disease, and from cancer of the rectum. Altered position of the limb, limitation of movement in the hip-joint, muscular wasting, and swelling soon arise in hip-joint disease.

In disease of the sacro-iliac joint examination shows that the movements of the hip-joint are unlimited and produce no pain, and that pain is developed by pressure over the sacro-iliac articulation and by pressing the ilia together. In infantile paralysis there is no pain, but there is paralysis with great muscular atrophy, which comes on with considerable rapidity. In spinal caries with psoas abscess the evidences of disease of the vertebræ are clear and a collection of fluid is located in the groin external to the femoral vessels. The tuberculous pus of hip-abscess generally gathers under the tensor vaginæ femoris muscle, but it may reach Scarpa's triangle by passing through the cotyloid notch or through the bursa under the psoas muscle; it may even appear under the glutei. Matter from a caseating acetabulum may reach the interior of the pelvis and appear above Poupart's ligament.

In gluteal bursitis the symptoms last for many months, and do not remit as the symptoms of early hip disease are apt to do. The pain is but moderate, and is aggravated by exercise, but passes away on going to bed, and is felt back of the hip and back of the knee. There are a certain amount of limitation of motion and a positive limp, which arises early. In marked cases fluctuation can be detected in the upper gluteal region.*

Prognosis.—If the case of hip disease is seen early, the chances of cure are excellent in children, in whom the disease may be arrested at any stage. The longer the duration of the disease and the older the subject, the more unfavorable is the prognosis. Many months will be required to elapse before a cure can be effected, and advanced cases only get well by means of ankylosis with shortening and deformity. Hip disease may recur years after apparent cure, and a person who has or has had hip disease runs a strong chance of developing visceral tuberculosis.

Complications.—The complications that may accompany hip disease are the following: *Abscess*, as above noted. *Tuberculous meningitis*, or the condition known as "acute hydrocephalus" or "water on the brain," may arise during the progress of the case or after apparent cure, and is apt to ensue upon incomplete operations. It is almost inevitably fatal. *Phthisis pulmonalis* is a rare complication, but is a common sequence, being apt to arise, sooner or later, after the hip disease is cured. *Amyloid*, *lardaceous*, or *waxy degeneration of viscera* follows upon profuse and long-continued suppurations and is apt to arise in the liver, spleen, kidneys, or intestinal mucous membrane. Tuberculosis is not the only cause of amyloid degeneration, syphilis being responsi-

* See E. G. Brackett's important paper on "Gluteal Bursitis" in the Transactions of the American Orthopedic Association, vol. x.

ble for at least 30 per cent. of all cases. In amyloid disease of the liver this organ is much enlarged, smooth, painless, and of increased consistency; there is no jaundice, the spleen is apt to be enlarged, and albuminuria is the rule. In amyloid kidney large amounts of pale urine of low specific gravity are voided; albumin is usually present in large amount, but may be absent; globulin may often be found, as may also hyaline, fatty, or granular casts; the patient is anemic, and dropsy usually exists. Test the hyaline casts with iodin for amyloid material. Amyloid changes are usually slow in onset, but they may be rapid; they are commoner in men than in women, and are most frequently encountered in individuals between the ages of ten and thirty. Slight amyloid change may be recovered from, but an extensive degeneration brings about a fatal result. Dickinson's theory of how this tissue-change is caused is that the flow of pus drains off from the body the alkaline salts, especially the salts of potassium, which drainage results in visceral depositions of de-alkalinized fibrin.

Fig. 290.—Thomas's posterior splint.

Treatment.—In most of these cases conservative treatment is advisable. Antituberculous treatment is used in all cases. In incipient hip disease the treatment consists in rest. Place the patient upon a solid mattress and apply extension. In children under ten years of age use a weight of from three to five pounds; in individuals between ten and twenty use a weight of from five to eight pounds. A long splint is often applied to the sound side to keep the patient recumbent and horizontal. Always use a cradle to hold up the bed-clothing. Apply the extension in the long axis of the limb, the extremity being placed in the line of the deformity due to disease and being properly supported. In lordosis from thigh-flexion, raise the limb until the iliac spine is straight (Pl. 7, Fig. 5). If the spine is depressed on the affected side, abduct the limb (Pl. 7, Fig. 6); if the spine is elevated, abduct the limb until the spines are horizontal (Pl. 7, Fig. 7). The object of extension is to overcome muscular spasm and so put the part in a condition of physiological rest. Muscular spasm is a great factor in destroying structures. Spasm presses the parts together, and as a result of pressure plus bacterial action destruction occurs. The extension and traction tire out the muscles and cause spasm to cease. Extension will remove flexion in two weeks in a recent case and in the course of some months in an older case. As flexion is relieved remove the pillows and lower the leg, but keep up extension in the long axis of the thigh. Abduction and adduction cannot be removed by simple extension in the axis of the limb.

Abduction demands no special treatment. In a movable joint it will disappear, and in an ankylosed joint it is an advantage, compensating by apparent lengthening for the shortening due to bone-absorption or to stunted growth of the limb. Adduction requires an addition of several pounds to the extension weight, the use of a long splint on the sound limb, and the drawing up of the sound side by a rope and pulley toward the head of the bed. The

weight used to pull the sound side toward the head of the bed is equal to that used to pull the damaged side to the foot of the bed. This expedient is used for a month or six weeks. In old cases where the weight will not bring about extension, anesthetize the patient, gently straighten the limb a very little, and reapply the weight.

Extension in a mild case must be continued for three months after the symptoms have disappeared, and in a severe case the period must be six months. The weight is gradually taken off; if symptoms recur, the weight is reapplied; if they do not recur, apply a traction splint or a plaster dressing, put a high-heeled boot on the sound limb, and send the patient out on crutches. In young children extension can be made while the child is in a wheeled

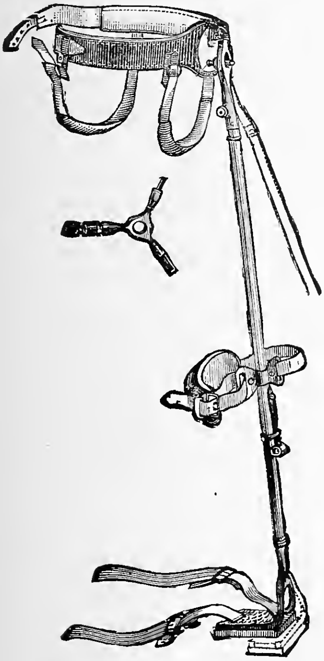


Fig. 291.—Sayre's long splint.

Fig. 292.—Wyeth's combination method.

carriage, thus enabling the patient to go out in the fresh air and sunlight. The general treatment is tonic and restorative. The joint is so deeply placed that external applications are useless. In the treatment of hip disease Thomas's splint (Fig. 290) is used by many, and it may be combined with weight extension; or Sayre's splint (Fig. 291) may be employed. Wyeth's apparatus (Fig. 292) is a favorite with many American surgeons.

If the limb is in good position, or has been brought into good position, either by weight extension or straightening under ether, plaster-of-Paris is a useful dressing. It is applied from the toes up, and includes the entire extremity and also the pelvis. A patient wearing plaster may get about on crutches when the sole of the foot of the sound extremity is raised by the wearing of a thick-soled shoe. If a case, in spite of treatment, does not improve or becomes

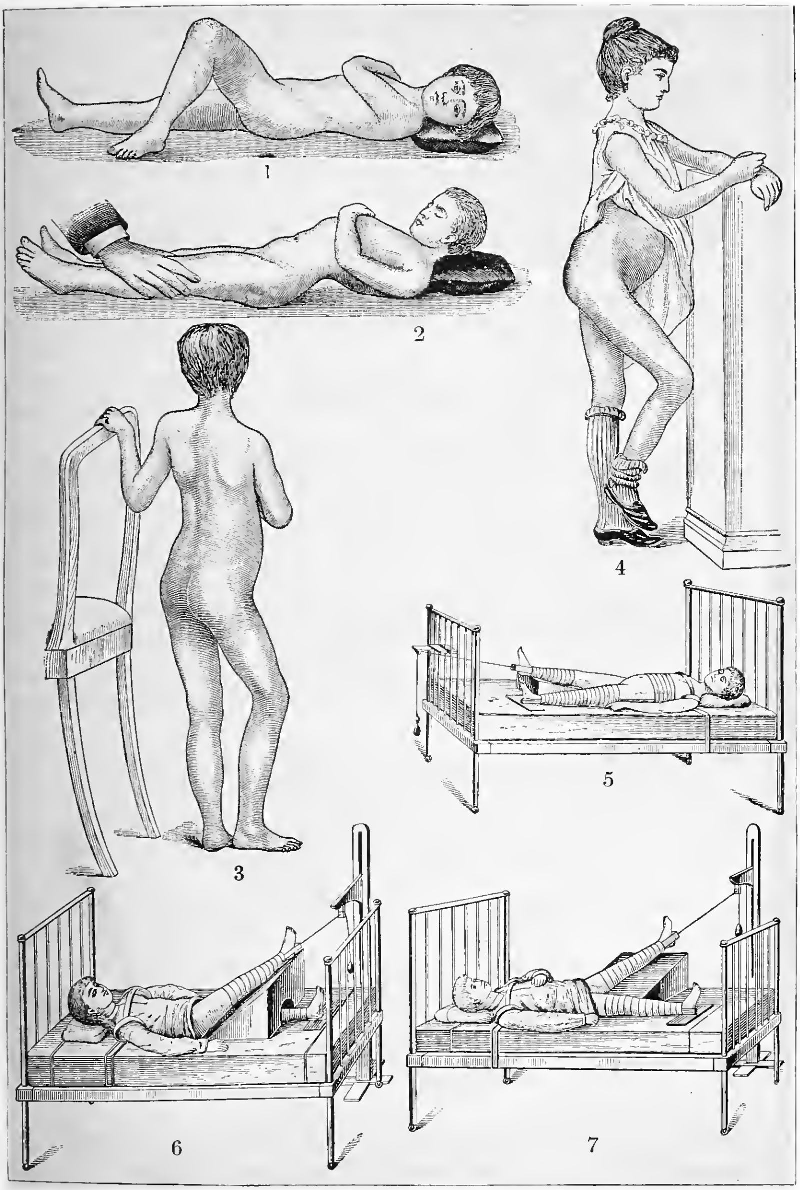
worse, use intra-articular injections of iodoform. Always try these injections before doing a resection unless the x-rays show a large sequestrum. Sometimes they succeed, and if they do, resection is unnecessary. Asepticize the surface, carry a small aspirating needle into the joint, irrigate the joint with salt solution, and inject a sterile emulsion of iodoform and glycerin (10 per cent.). In one week, if reaction has ceased, repeat the injection. In another week repeat it again. It may be necessary to give from ten to twenty injections. The proper spot for puncture is thus determined. Draw a line from a point half an inch outside of the middle of Poupart's ligament to the outer edge of the great trochanter. Puncture at the middle of the outer half of this line (De Vos). I have not attempted to remove the disease surgically early in any case and greatly doubt the wisdom of doing so. Huntington and some other surgeons advocate early operation in children instead of simply fixation, extension, and rest. Huntington ("Am. Jour. Med. Sciences," July, 1905) recalls that when the lesion is in the head of the femur, it tends to perforate into the joint and he advises trephining at the lower border and outer aspect of the great trochanter and tunnelling the neck and head of the femur with a curette. Bradford objects to this method in most cases on the ground that unless the disease is localized and the cavity is well walled off and unless injury to the localizing barrier is avoided, the operation may be responsible for dissemination of the bacteria.

If an abscess forms, incise it with the most thorough antiseptic care, let the fluid drain away, irrigate the cavity with salt solution, remove any sequestra, inject with iodoform emulsion, sew up without drainage, and dress antiseptically. In some cases the sequestrum is extra-articular. In many cases no sequestrum is found. If this method fails, drainage must be employed. The old plan of not operating until rupture was seen to be inevitable was wrong. To open early and antiseptically often means rapid healing, the prevention of burrowing, a lessened danger of visceral infection, and an earlier cure. In contrast to what happens when a very large cold abscess is opened hectic will rarely arise when a tuberculous joint is opened with antiseptic care.

Excision of the hip is to be performed when there is a large sequestrum or severe fistulæ (Garre, "Deutsch. med. Woch.," 1905, Nos. 47 and 48); when the head of the femur is detached and lies loose in the joint; when profuse suppuration continues for a long time, and other methods fail to arrest it; when amyloid disease is threatening; or when very faulty position is inevitable without operation. Excision is an operation of considerable danger, and the older the person, the greater the danger. Schede advocates arthrectomy in some cases as a substitute for resection. Senn tells us that opinion as to resection has greatly changed of late, and it is now taught that the operation is advisable in all cases where fixation, extension, intra-articular and parenchymatous injections have failed to arrest the disease (Senn on "Tuberculosis of Bones and Joints"). Resection of the hip does not give a very satisfactory functional result. When there is extensive disease of the femur, when excision has been tried and has failed, when the patient has not the recuperative power to withstand the long siege of illness following excision, or when there is amyloid disease, amputate.* Amputation of the hip-joint for tuberculous disease is a very successful procedure.

Knee-joint Disease (*White Swelling*).—After the hip, the knee is, of all

*See the admirable article of Howard Marsh in Treves's "Manual of Surgery."



1, 2. Effects on the Lumbar Spine of Flexing and Extending the Diseased Leg in Hip Disease (Albert). 3, 4. Positions in Coxalgia (Albert). 5. Extension in Hip Disease (Treves). 6. Extension of the Limb in a Flexed and Adducted Position (Treves). 7. Extension of the Limb in a Flexed and Abducted Joint (Treves).

joints, the commonest site for tuberculous disease. Knee-joint disease can begin as a synovitis, but oftener begins as tuberculous inflammation of the femoral or the tibial epiphysis. Tuberculous disease rarely attacks the bone on the diaphyseal side of the epiphyseal line; a single focus only exists, as a rule, and a sequestrum is rarely formed. In very rare instances the patella or the semilunar cartilage is primarily attacked. It may begin at any age, but is most common in children and young adults. If an acute synovitis ushers in the case, there may be a large effusion into the knee-joint and partial flexion, but swelling is usually slight in knee-joint disease. Pulpy degeneration of the synovial membrane occurs; the joint enlarges; the ligaments soften; the skin becomes edematous, and muscular spasm arises. The leg becomes flexed; the bones displaced backward and outward; the foot everted; and lameness arises, due chiefly to deformity. Pain may be absent, is often slight, and is rarely severe. When the disease begins in the bone or an epiphysis there are pain, tenderness, lameness, swelling, inability to extend the limb completely, sudden spasmodic muscular contractions, and final involvement of the joint. When an abscess forms, it may destroy the joint very rapidly or it may break externally.

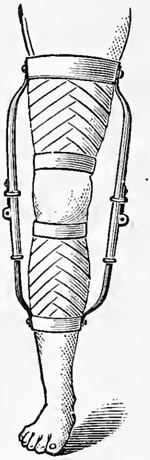


Fig. 293.—Sayre's knee splint applied.

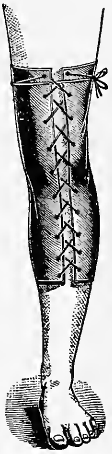


Fig. 294.—Hutchinson's knee-joint splint.

Treatment.—In treating knee-joint disease conservative treatment is usually tried but often fails. A plan of doubtful value is to make a mixture of guaiacol and tincture of iodin or guaiacol and olive oil (1 : 4). Once a day the surface of the knee is exposed by removing dressings, is painted with this mixture, and the painted surface is covered with cotton-wool. Rest is of the first importance, and may be secured by the application of splints (Figs. 293, 294), the use of extension (Fig. 295), or the employment of a plaster-of-Paris bandage. In any case the patient must be kept in bed for a few weeks; he may then be permitted to go out upon crutches, wearing a high-heeled shoe upon the foot of the sound limb. In cases in which treatment is begun early the disease may often be arrested in from eight to twelve months. If the symptoms do not abate after a number of weeks, or if the condition grows worse and caseation occurs, aspirate, irrigate, and inject iodoform emulsion. Intra-articular injections are not unusually curative. Insert the needle in the angle between the outer edge of the patella and the ligament of the patella (De Vos). Repeat the injection in one week if reaction has abated, and continue as directed for the injection of the hip-joint. If this plan fails, incise the capsule, remove all fragments and tuberculous foci, irrigate with normal salt solution, inject iodoform emulsion, and sew up without drainage (Neuber's plan). A more severe case requires drainage. If these means fail, or if the case is too far advanced to permit of their use, open the joint and perform an excision or an erasion (page 628). Excision gives a satisfactory result in most cases,

although it leaves a stiff knee and marked shortening. Garre considers any shortening over 5 cm. a bad result, and he got such a bad result in 7.5 per cent. of his 117 cases. In children shortening follows even conservative treatment, and the shortening which follows excision is due in part to removal of bone and in part to impairment of the nutritive power of the epiphyseal cartilage. Some cases demand amputation, which, if the patient's health is much impaired or if amyloid disease exists, is to be preferred to excision. Amputation is preferred to excision in very young children and aged people.

Ankle-joint disease may begin in the synovial membrane, in the tibial epiphysis, or in the tarsus, but the origin is usually synovial. The *symptoms* are pain, swelling, lameness, limitation of joint-movements, and atrophy of the calf-muscles. Caseation often occurs, and sinuses form.

Treatment.—Conservative treatment with iodoform injections will cure many cases. Rest is obtained by means of splints or plaster-of-Paris bandages. Caution the patient to avoid standing upon the diseased extremity. In injecting iodoform emulsion insert the needle below the outer malleolus. When caseation occurs, it is advisable to open the joint, wash out with normal salt solution, inject iodoform emulsion, sew up the incision, and put up

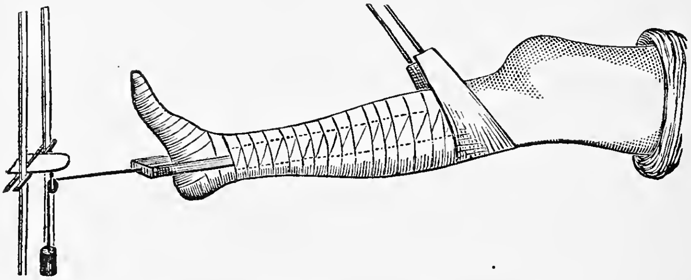


Fig. 295.—Sayre's double extension of the knee-joint.

the ankle-joint in plaster. When there is considerable bone disease, when fistulæ exist, when adjacent joints or tendons are diseased, or when joint-disorganization occurs, perform an excision or an erasion. Some cases demand amputation (Syme's amputation being preferred by some, amputation above the ankle being approved by many). Osteoplastic resection is sometimes advised (Wladimiroff-Mikulicz operation). Operative treatment is more satisfactory in children than in adults (Garre).

Shoulder-joint disease is not common; it is rare in children and is commonest in adults; it may begin in the synovial membrane, but usually begins in the head of the humerus. The glenoid cavity is rarely attacked. Pain is slight, atrophy of the deltoid and other muscles is noted, the joint is stiff, and the scapula follows the motions of the humerus. Caries sicca is the usual cause of destruction. In many cases swelling is not obvious, the joint shrinking because of destruction of the head of the bone and contraction of the capsule (Senn). Abscess-formation is unusual. If an abscess forms, it may open in the axilla, through the deltoid muscle, or at some far distant point. It is frequently complicated by pulmonary tuberculosis.

Treatment.—A majority of cases recover from conservative treatment, a

stiff joint resulting. Put on a shoulder-cap, apply the second roller of Desault, and hang the hand in a sling. Maintain rest for at least four months. Aspiration and injection of iodoform emulsion are of great service in synovial tuberculosis. The needle is entered below the acromion, while the arm is held against the side and the forearm is at right angles to the arm and across the front of the chest (De Vos). If caseation occurs, open the joint, remove tuberculous foci, wash with hot saline fluid, inject iodoform emulsion, and close without drainage, or, in a rather severe case, drain. In rare instances dead bone will have to be gouged away. Caries sicca may occur. Excision is sometimes required, but the results are seldom satisfactory.

Elbow-joint disease may begin in the humerus or the ulna. The head of the radius is rarely the primary focus. In some cases the synovial membrane is first attacked. The disease is most frequent in young adults. The joint is swollen, its movements are somewhat limited, muscular wasting is pronounced, and pain is generally slight. Tuberculous pus may form.

Treatment.—In treating early elbow-joint disease, especially in young children, conservative treatment is very successful. Rest is secured by means of an anterior angular splint (Fig. 296) and a triangular sling or a plaster-of-Paris dressing. Splints are to be worn for from four months to a year. Injections of iodoform emulsion are usually employed. Insert the needle for injection by the side of the olecranon. In a cure by conservative methods a stiff joint will result. It may be necessary to perform resection because of extensive bone disease. Resection gives an excellent functional result.

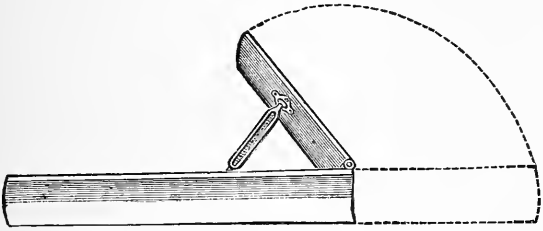


Fig. 296.—Stromeyer's anterior angular splint.

Wrist-joint disease may arise at any age, and is sometimes met with in late middle life or even in old age. The joint presents a puffy swelling, loses its normal contour, and becomes spindle-shaped. Hand-movements are impaired, pronation and supination cannot completely or satisfactorily be performed, the joint is stiff and partly flexed, the grasp is enfeebled, pain may be severe or slight, the skin is sometimes but seldom hot, and muscular atrophy is marked. This form of tuberculosis may begin in the synovial membrane, in the bones, or in the tendon-sheaths.

Treatment is usually conservative and very successful, giving, as a rule, a functionally useful joint and movable fingers. Garre recommends a trial of the method even when there are fistulæ and when there is necrosis of the carpus. Apply a Bond splint and sling or put on a plaster-of-Paris bandage and maintain strict rest for from four to six months. Aspiration and injection of iodoform emulsion are used. Enter the needle at the dorsal edge of the

radial styloid process, and again at the upper edge of the pisiform bone (De Vos). In some cases it is well to incise, wash with salt solution, inject iodoform emulsion, and close without drainage. Severe cases demand incision and drainage with the maintenance of rest. Resection is to be avoided if possible. It gives a bad functional result, the amount of bone removed leaving the tendons too long and contractions of muscle being common (Garre). It may be demanded because of extensive caries or sequestra formation. Amputation is occasionally necessary.

Acute Suppurative Arthritis.—This infection is usually due to the staphylococcus pyogenes aureus or to the streptococcus pyogenes, which find entrance by means of a wound, by the spontaneous evacuation into a joint of the products of an osteomyelitis, by extension of suppurative inflammation through contiguous structures, or by the blood-stream. In this disease all the joint-structures are involved and suppuration rapidly appears. It is very rarely due to gonorrhea, and sometimes to septicemia.

Symptoms.—The symptoms of acute suppurative arthritis are usually a chill followed by fever and a rapid pulse. There are severe pain, which is aggravated by motion and is worse at night; discoloration, heat, and edema of the skin; partial flexion of the joint; fluctuation; and marked constitutional symptoms of sepsis. The joint tends to rapid disorganization, and fatal septicemia is very apt to occur. In pyemic arthritis several joints become infected.

Treatment.—The treatment in this form of arthritis consists in prompt incision, evacuation, antiseptic irrigation, drainage, antiseptic dressing, and immobilization. Cure is followed, as a rule, by ankylosis, but in cases treated early a movable joint may be preserved.

Infective arthritis arises in the course of an acute infectious disease (such as erysipelas, typhoid fever, pneumonia, influenza, mumps, dysentery, diphtheria, measles, scarlatina, variola), and may be due to pyogenic cocci, to the specific micro-organism of the acute infectious disease, or purely to microbic products. Joint-inflammation arising in the course, or as a sequel, of an acute infectious disease may or may not suppurate.

Symptoms.—If no suppuration takes place, the *symptoms* of the attack resemble those of rheumatism; if suppuration occurs, the symptoms are the same as those of acute suppurative arthritis, with which disease this form of infective arthritis is identical. Suppuration rarely occurs. Ashby has well described the arthritis which sometimes follows *scarlatina*. It involves the wrists, finger-joints, tendons of the forearms, the knees, ankles, or spine. The joints are painful, but are rarely much swollen or discolored (Howard Marsh). We can distinguish infective arthritis from rheumatism by the fact that it does not migrate and is uninfluenced by antirheumatic remedies.

Treatment.—The treatment of a mild case is identical with that used for simple synovitis: if there is much fluid in the joint, aspirate and wash with normal salt solution. If pus forms, open, irrigate, and drain.

Typhoid Arthritis.—This disease is a form of infective arthritis. That the bacteria of typhoid may inflame the joints is proved, and it seems certain that they can cause suppuration, although their pathogenic power has been disputed. Some claim that mixed infection is the real cause of suppuration. The typhoid bacilli enter the bones in many typhoid cases and sometimes cause bone-disease. Joint-disease is more common than bone-disease

Typhoid disease of a joint begins when the fever is abating, and more than one joint may be involved. Typhoid joints may recover permanently, may become ankylosed, may dislocate, or the joint-disease may lead to fatal sepsis. In slight cases the synovial membrane only is involved; in more severe cases capsule, cartilages, ligaments, and even bones are involved. Some cases suppurate. Keen tells us that septic typhoid arthritis results from a mixed infection with typhoid bacilli and pyogenic bacteria, and is identical in symptoms and progress with an ordinary septic arthritis. The same author points out that typhoid arthritis proper may be monarticular or polyarticular, the monarticular form being the most common, and the hip-joint being the articulation most liable to attack. In most cases typhoid arthritis causes but little pain. The swelling is marked, although in the hip it is concealed. Pus rarely forms. Keen calls attention to the fact that in the eighty-four cases he collected, spontaneous dislocation occurred in forty-three, nearly all in the hip.*

Treatment.—A mild case is treated as a simple synovitis. If diagnostic puncture obtains fluid free from bacteria, no more radical method than aspiration and irrigation is required. If the fluid contains bacteria, incision and drainage are demanded.

Gonorrheal Arthritis or Gonorrheal Rheumatism.—During the progress of gonorrhea the development of a painful joint does not of necessity prove the existence of gonorrheal rheumatism, for ordinary rheumatism is just as likely to arise when a man has clap as when he has not this malady. Furthermore, the term is inaccurate, as gonorrheal rheumatism is not rheumatism at all, but is an infective disorder of the joints or of the synovial membranes, the infective material being contained primarily in the urethral discharge. Gonorrheal rheumatism is one of the forms of infective arthritis. Occasionally this form of arthritis arises from gonorrheal ophthalmia (Heiman's case); it sometimes, though rarely, arises during the height of a gonorrhea, but it is more frequently met with in chronic cases or when the intensity of the inflammation is abating in acute cases. Men suffer from gonorrheal arthritis far more frequently than do women, and the seizure is very apt to recur again and again. In some cases many joints are involved, but in most cases only a few joints suffer. Osler states that the knees and ankles are most apt to be involved in gonorrheal rheumatism, and that this form of arthritis is peculiar in often attacking joints that are apt to be exempt in acute rheumatism ("the sternoclavicular, the intervertebral, the temporomaxillary, and the sacro-iliac"). There are two forms of gonorrheal rheumatism—an acute and a chronic form. The poison reaches the joint by way of the blood. In some cases gonococci are found in the joint fluid; in other cases they are not found. I am inclined to believe that in the milder cases, which recover without genuine pus-formation, only toxins are present in the joint. In the severe cases the organisms themselves exist in the articular fluid. Osler suggests that the non-suppurative cases are due to the action of toxins taken up from the area of primary infection, and that the suppurative cases are due to infection with pyogenic bacteria. Endocarditis may occur, and it is due always to micro-organisms and not to toxins.

Changes in and about the Joint.—The inflammation of gonorrheal arthritis

*Keen on "The Surgical Complications and Sequels of Typhoid Fever."

may be located around rather than in the joint, and especially in the tendon-sheaths. Suppuration is unusual, but it may occur in joints and in tendon-sheaths. Cultivation of the exudate may or may not show the gonococci. Cover-glass preparations carefully stained may or may not show gonococci.

Symptoms.—The acute form attacks, as a rule, but a single joint, but may attack several joints. The joint trouble begins with great suddenness, and is often ushered in by chilly sensations or by a distinct chill. Moderate fever arises. The pain in the joint, severe from the first, becomes excruciating. If superficial joints suffer, the skin over them becomes red and hot, and periarticular edema soon presents itself. The fluid in the joint is in most cases serous, but may become purulent. If pus forms, the fever becomes very high and chills may occur.

A chronic condition may follow the acute, but the condition may be chronic from the start. The symptoms resemble those of the acute form, but are far milder, although acute exacerbations may occur. The joint fluid is usually serous.* In gonorrheal arthritis there may be transitory, intermittent, and wandering pain in and about the joint, without any other symptom; one or more joints may become swollen and painful, and moderate fever may develop. One joint, especially the knee, may swell to an enormous extent, pain, pariarticular edema, redness, and fever being absent (hydrarthrosis, or dropsy of the joint). Suppuration in this form of the disease seldom occurs. The tendons, the tendon-sheaths, the bursæ, and the periosteum may inflame. Whether the joints are inflamed or not inflamed, the tendon-sheaths about the wrist and ankle and the retrocalcaneal bursæ may suffer. In some cases numerous bursæ are involved. It is often difficult and is perhaps impossible to check gonorrheal arthritis. It may last for a long period, and tends to recur again and again. Iritis, pleuritis, endocarditis, and pericarditis have been observed as complications.

The *diagnosis* between gonorrheal arthritis and acute rheumatism rests chiefly on the great chronicity, the slight degree of fever, the excessive tendency to recurrence, and the absence of profuse acid sweats in gonorrheal rheumatism; and on the shorter course, the higher fever, the profuse acid sweats, the lesser tendency to rapid recurrence, the greater proneness to symmetrical involvement, and the great liability to cardiac and visceral complications in rheumatic fever. Furthermore, in gonorrheal arthritis a gonorrheal infection (urethral or ocular) certainly exists or recently existed; in ordinary rheumatism a urethral discharge may, of course, happen to be present. Gonorrheal arthritis is apt to affect certain joints which acute rheumatism rarely attacks.

Treatment.—The salicylates, the alkalies, and salol are useless; iron, arsenic, and strychnin are possibly of some benefit. Quinin is helpful in some cases. Iodid of potassium seems to be of a certain amount of value. The inflamed joints should be wrapped in cotton and bandages, and every day a little blue ointment should be rubbed into the skin about them. If the inflammation lingers, use the hot-air oven, massage, and gentle passive motion, apply blisters, or counter-irritate with the hot iron. If the inflammation still lingers, or if it becomes worse, aspirate, wash out the joint with hot

* See Schuller in Aerztl. Pract., No. 17, 1896.

normal salt solution, and inject iodoform emulsion. If pus forms, incise, irrigate, drain, and immobilize.*

Pneumococcus Arthritis.—This is a rare condition, although Herrick has collected 52 cases ("Amer. Jour. of Med. Sciences," July, 1902). Examination of the blood may or may not discover pneumococci, and pneumococci may be found in the blood during pneumonia, when the joints are free from disease. The inflammation may attack any joint, but is most apt to arise in a joint weakened by previous injury or damaged by rheumatism or gout. Alcoholics are more prone to suffer than others. In a great majority of cases the disease is associated with lobar pneumonia, but Cole's case proves that the lung may be free ("American Medicine," May 31, 1902). As a rule, a single large joint is attacked, and the knee is most liable to suffer. The synovial membrane alone may be involved or cartilages may suffer and bone be attacked. The fluid may be serous, but is usually purulent (Herrick). I have seen 2 cases: in one case the knee only was involved; in the other, both knees, one elbow, and one shoulder were attacked. In Cole's series of 41 cases, 13 exhibited involvement of more than one joint. The inflamed joint is frequently completely destroyed. Pneumococcus arthritis develops, as a rule, soon after the crisis of pneumonia, but Herrick says it may arise as late as three weeks after the crisis.

The diagnosis is made by the history of pneumonia, the development of septic symptoms, and the signs of joint inflammation. It is confirmed by aspiration and examination of the fluid. The disease is very fatal. In Herrick's series of cases over 65 per cent. were fatal. In Cole's series of cases there were 28 deaths and 13 recoveries. Even if the patient recovers, the convalescence is prolonged and more or less ankylosis is to be expected.

Treatment.—A non-purulent effusion may be treated by aspiration if bacteria are not found in the fluid. If the aspirated fluid contains bacteria, the joint should be opened and drained.

Acute Rheumatic Arthritis; Rheumatic Fever or Acute Rheumatism.—Acute rheumatism is a self-limited febrile malady whose characteristic features are polyarthritis, profuse acid sweats, and a tendency to heart-involvement. There is some evidence to indicate that acute rheumatism is a form of infective arthritis, the bacteria being deposited in the synovial tissues and later perhaps entering into the joint cavity. Arthritis of many joints has followed intravenous injection into animals of diplococci obtained from the throat of a man suffering from rheumatic angina (Poynton and Paine at Manchester meeting of the Brit. Med. Assoc., 1902). John O'Conor † believes that acute rheumatism is a condition "something similar to gonorrheal arthritis and pyemia, the germ or toxin gaining admission to the body through the tonsil or other microbic trap-door, and that the joint invasion is promptly followed by a form of infective arthritis accompanied with general toxemia; and, furthermore, the infected joints serve as incubators, where the poison is elaborated and passed into the circulation and thus conveyed to other articulations and to the heart."

Symptoms of Acute Rheumatism.—In acute rheumatism the case begins

* See Schuller, Aerztl. Pract., No. 17, 1896, and Monats. über d. Krankheiten d. Harn- und Sexual-Apparatus, 1897, p. 30.

† Lancet, Jan. 24, 1903.

with malaise and fever, and one or more joints become affected. The inflammation spreads from joint to joint, is apt to be symmetrical, and when it arises in fresh joints, usually disappears quickly in those previously affected. The temperature is high, the skin sweats profusely, the joints are red, swollen, hot, and excruciatingly painful, and the structures about the joints are edematous. After a short time the inflammation subsides in one joint and passes into another, the joint first attacked regaining its functions. Suppuration does not take place. Anemia is pronounced, exhaustion is profound, the sweat is sour, the saliva is acid; the urine is acid, scanty, high-colored, often contains albumin, and is deficient in chlorids. Cardiac disease is apt to be produced (endocarditis, pericarditis, or myocarditis). Nodules may form upon fibrous structures hyperpyrexia is not unusual, and cerebral or pulmonary complications may occur.

Chronic Rheumatism.—Sometimes follows repeated attacks of acute rheumatism, but oftener arises insidiously in people who have been exposed to cold and damp, who have suffered from poverty, hardship, and privation, or have had much worry. The capsule and tendon-sheaths thicken, and there is usually but little effusion in the joint, but the articulation becomes stiff and painful. The joint-cartilages are occasionally eroded. Muscular atrophy occurs.

Symptoms of Chronic Rheumatism.—In chronic rheumatism the affected joints are stiff and painful and are a little swollen, but not red. Dampness and cold aggravate the symptoms. One joint or many may be affected, but usually several are involved. Passive movements cause the joint to creak and develop crepitus in the tendon-sheaths. The muscles are wasted. Anemia is usually pronounced. The smaller blood-vessels become surrounded by fibrous tissue which progressively contracts and lessens the blood-supply of the synovial structures. The joints may ankylose. There is no fever and no tendency to suppuration, and the disease is incurable.

The *treatment* of acute rheumatism comprises the use of alkalies, salicylates, etc. (See a book upon practice of medicine.) O'Conor is a believer in incising and draining the inflamed joints; and if the theory of an infective origin is correct, this treatment is rational. I have never ventured to do it, but would consider the advisability of doing so if the ordinary treatment proved futile. O'Conor operates early and believes that this is the real way to arrest the disease and prevent complications, but his views have not met with general acceptance.* In *chronic rheumatism* maintain the general health of the patient, give courses of iron, arsenic, and strychnin, and an occasional course of iodid of potassium or a salt of lithium, and, if possible, send him every winter to a warm climate. Turkish baths give considerable temporary relief. The waters and regimen of Carlsbad and Vichy are of positive though temporary benefit, and the sufferer may obtain relief at the hot springs of Virginia. The patient must avoid damp and must wear woolens. Frictions, the douche, massage, flying blisters, counter-irritation with the hot iron, ichthyol ointment, and mercurial ointment are of benefit. Subjecting the diseased joint to a very high temperature by placing it daily in a hot-air apparatus often does great good. In partial ankylosis it is proper in some cases to give ether and break up the adhesions.

* Lancet, Jan. 24, 1903.

Gouty arthritis, which appears especially in the smaller joints (as the fingers and the metatarsophalangeal joints of the great toes), is due to a deposition of urate of sodium in the joint and in the periarticular structures. The irritant urate of sodium causes inflammation, inflammation leads to the formation of granulation tissue, granulation tissue is converted into fibrous tissue, and the fibrous tissue contracts and thus deforms the joint and limits its mobility. A great mass of urates in a joint constitutes a "*chalk-stone.*"

Symptoms.—The premonitory symptoms may be observed for a day or so, but the acute seizure usually occurs early in the morning, the patient, as a rule, being aroused by excruciating pain in the metatarsophalangeal articulation of one of the great toes. The joint swells, and the skin over it feels hot to the touch and becomes red and shiny. There is often considerable fever. After a few hours the intensity of the seizure abates, only to recur

Fig. 297.—Chronic gout.

again with renewed violence early the next morning, these remissions and recurrences taking place for six or eight days, when the attack subsides. In patients with *chronic gout* (Fig. 297) many joints are stiffened and deformed as a result of repeated attacks. Chalk-stones form, and the skin above them may ulcerate. Such patients are chronic dyspeptics, have high-tension pulses, their hearts are hypertrophied, and their urine contains albumin and casts.

The *treatment* of gouty arthritis belongs to the physician, and not to the surgeon, although to the latter the symptoms of the disease should be known, so that it may be diagnosticated from other maladies.

Osteo-arthritis (*Rheumatoid Arthritis; Arthritis Deformans; Rheumatic Gout.*—In this disease, which is not a combination of gout and rheumatism,

the synovial membrane and cartilages are affected, the periarticular structures are involved, and masses of new bone are formed.

Osteo-arthritis probably has, as John K. Mitchell long ago pointed out, a nervous origin. It arises especially in persons who have been worried, driven, and harassed. There is apt to be muscular atrophy, trophic lesions of the hair and nails are likely to appear, and the symptoms are disposed to be symmetrical. The causative lesion has not been determined. The disease is commoner in women than in men. The greatest liability exists between the ages of twenty and forty, but children may acquire the disease, and it may also be developed in people far beyond middle life. Apes in captivity may develop it. Arthritis deformans may attack the rich or the poor; it does not result from gout, nor does it often follow rheumatism; it is not caused by damp and cold; and only in rare cases does it arise after traumatism of a joint.

Osteo-arthritis differs from gout in the entire absence of urate deposit, and it differs from chronic rheumatism in the extensive alterations in the joint-structures. The changes begin in the cartilage; the cartilage-cells multiply, the intercellular substance degenerates, the pressure of the bone causes thinning, and at length the cartilage is entirely destroyed and the bone exposed. The exposed bone is altered in shape, is hardened, and is worn away in the center, the periphery increasing in thickness by ossific deposit, the center deepening by absorption. The margins are not only thickened, but are bulged and lengthened by deposit. The fringes of the synovial membrane hypertrophy and multiply, and some of them are apt to break off (*loose cartilages*). The capsule and the ligaments of the joint, as a rule, become fibrous and contract; but they may soften, relax, and permit of dislocation. The joint usually contains no effusion, but in some cases there is great effusion (*hydrarthrosis*). The tendons about the joint may become fibrous and contracted, they may ossify, they may be separated from the bone, or they may be destroyed entirely. Deformity is marked and motion is limited. The fingers, when involved, show nodules on the sides of the joints (Heberden's nodules). The vertebræ may be involved. Almost all the joints may suffer. Suppuration does not occur.

Symptoms.—Charcot divides osteo-arthritis into three forms, and gives their symptoms, as follows:

1. *Heberden's nodosities*, which condition is commoner in women than in men, comes on between the ages of thirty and forty, and is especially common in neurotic subjects. The interphalangeal joints become the victims of attacks of moderate swelling and of some tenderness, which attacks are not severe, but recur again and again. After a time small hard swellings (nodosities) appear upon the sides of the dorsal surface of the second and third phalanges, remain permanently, and slowly increase in size. The joints become stiff and creak on movement, the cartilages are destroyed and contractions and rigidity develop, but there is no fever and the larger joints are not involved. The malady is incurable.

2. *Progressive rheumatic gout*, which may be acute or chronic. The *acute* form begins as does rheumatic fever. There are moderate fever and swelling, without redness, of a number of joints, of bursæ, and of tendon-sheaths; the joints are stiff and crepitate, and are apt to be symmetrically involved; muscular atrophy begins early and rapidly becomes decided; pain is slight.

This acute form is apt to arise in young women after pregnancy, but is not unusual at the climacteric and in children. Anemia always exists. The case is apt to advance progressively until a number of joints are firmly locked, when it may become stationary. Another pregnancy will develop anew the acute symptoms. In the *chronic* form swelling and pain on movement are noted in certain joints. The involvement is apt to be symmetrical. Attacks of swelling and pain alternate with periods of quiescence, but the disease does not cease its advance. Articulation after articulation is attacked by the malady until almost all the joints are involved; deformity and stiffness become pronounced, and pain may or may not be severe. There is no fever. Muscular atrophy is marked.

3. *Partial rheumatic gout* attacks one articulation, and it is most often met with in old men. It may fix itself on the vertebral column, on the knee, on the shoulder, on the elbow, or on the hip. The joint grates and becomes stiff, swollen, and deformed; the muscles atrophy; there is usually pain, but fever is absent.

Osteo-arthritis or partial rheumatic gout of the hip-joint seldom occurs before the age of forty-five, but is occasionally, though very rarely, met with in persons under twenty-five. If the disease arises in an elderly person, it is often called *morbus coxæ senilis*. In some cases only the hip-joint is attacked; in many cases other joints are also diseased. Osteo-arthritis of the hip may follow an injury. Usually the disease is unconnected with traumatism, begins very gradually, and advances slowly. There is pain, often mistaken for sciatica, in and about the joint, and there is increasing stiffness. The pain and stiffness are worse when the patient first moves after resting. Lameness becomes noticeable, and grating can be detected in and about the joint. The symptoms become gradually worse, although at times they may seem to improve for brief periods. The lameness and the stiffness are greatly aggravated, and the pain becomes very severe, even when at rest. Shortening takes place, the great trochanter ascends above Nélaton's line, the limb is usually abducted, but in very rare cases is adducted, and finally ankylosis occurs.

Partial rheumatic gout of the vertebral articulations causing fixation is called "*spondylitis deformans*" (p. 752).

Treatment.—Osteo-arthritis cannot be cured, but in some cases it remains stationary for many years. Treat the anemia by iron, arsenic, nourishing food, and have the patient out in the fresh air as much as possible. Debility is met by the administration of strychnin. Hot baths of mineral water do good. It is claimed that the hot-air apparatus is of service. Douches improve these cases, but electricity is useless. Counter-irritants do no good. Massage retards the progress of the case, relieves the pain, aids in the absorption of effusion, and delays fixation. During an acute exacerbation the joint should be put at rest for a time and evaporating lotions applied. In an exacerbation in disease of the hip the patient should be put to bed and have extension applied. The patient is unfortunately liable to develop the opium-habit. If dropsy of a joint arises, try compression with a Martin bandage, and, if this fails, aspirate and wash out the joint with a 2 per cent. solution of carbolic acid. Patients with rheumatic gout do best in a warm, dry climate. Cod-liver oil does good, as it improves nutrition and hence

retards the progress of the disease. Do not be tempted to immobilize the joints beyond a day or two: fixation only hastens ankylosis. Howard Marsh* maintains that, as a rule, but little good comes from manipulation. He makes the following exceptions: when one joint only is affected; when the joint is very stiff but not very painful; when the patient is in good general health and is not beyond middle age.

Charcot's Disease (*Tabetic Arthropathy; Charcot's Joint; Neuropathic Arthritis*).—This condition is an osteo-arthritis due to trophic disturbance, arising in a sufferer from locomotor ataxia, and is anatomically identical with osteo-arthritis, which was described above. The knee is most apt to be attacked, and the hip suffers more often than any joint but the knee. The condition may develop in the shoulder or elbow. The smaller joints sometimes, though seldom, are involved. More than one joint may suffer. The disease in most cases begins acutely, often as a sudden effusion, which after a time may disappear. In most cases, however, the joint becomes rapidly disorganized. The swelling is usually very marked and is sometimes enormous. In the earliest stages it is due to periarticular edema and to articular effusion. Pain is slight or is absent, there is no constitutional involvement, and the condition is unconnected with injury. Some cases begin without this preliminary acute swelling, disorganization being manifest from the beginning. When disorganization has once begun, it continues inexorably. Bony masses form around the articular cavity, in the ligaments, and in the cartilages. The bones and cartilages are rapidly destroyed and absorbed; fracture is apt to occur; the joint creaks and grates; the softening and relaxation of the ligaments permit an extensive range of movement; great deformity ensues; dislocation is apt to occur; muscular atrophy is decided; and pus occasionally, though very rarely, forms. There is not the slightest disposition to repair. Charcot's joint differs from rheumatoid arthritis in the usual acute onset and the painless course. The complete or nearly complete freedom from pain is one of the most striking features of the condition. In saying there is freedom from pain we mean freedom from pain in the joint, from the pain and tenderness in the regions in which we expect to find them in an inflamed joint. Usually these patients, though free from pain in the joint, suffer much from the lightning pains of locomotor ataxia. Gastric crises are not uncommon (Bramwell). Charcot's joint is more common in female than in male tabetics. In saying that Charcot's is often of sudden origin, we mean in a single night, as Charcot pointed out, swelling of a joint may arise. In a day or two the joint swelling becomes great, and if aspiration is performed, yellow serum is obtained. In a week or two the joint begins to creak on movement.

Treatment.—The treatment of Charcot's disease consists in the wearing of an apparatus to sustain the joint. Resection is recommended by some, but most surgeons do not advise its performance. Southam advocates amputation for certain cases of Charcot's joint. He has performed the operation on four patients. He amputated twice for ankle-joint disease and twice for disease of the tarsus. In every case the stumps healed quickly and without suppuration. Southam was lead to perform amputation on his first case by the report of Jonathan Hutchinson's case of amputation of the leg for perforating ulcer and disease of the bones of the foot in a tabetic.

* "Diseases of the Joints and Spine."

Osteo-arthropathie Hypertrophiante Pneumique (*Marie's Disease*).—A condition associated with, and possibly springing from, pulmonary disease, and characterized by enlargement of joints, thickening of the finger-ends, and the formation of a dorsolumbar kyphosis. The joints are painful, the skin undergoes pigmentation, and profuse perspiration is often present. The head entirely escapes in this disease, which immunity marks a distinction from acromegaly.

Hysterical joint (*Brodie's joint*) is a condition mostly encountered in young women. The disease occurs most commonly in the knee and the hip, and often follows a slight injury which acts as an autosuggestion, a latent hysteria being awakened into action and localized, though severity of the injury does not determine the severity of the symptoms. The disease may ensue upon a synovitis or an arthritis, or may arise without apparent cause. The patient complains of pain in and stiffness of the joint, resists passive motion strenuously, and claims that it causes much pain. There is occasionally some muscular atrophy from want of use, and the joint is a little swollen. The skin is hyperesthetic, and a light touch causes more pain than does deep pressure. The muscles may be rigid. The joint may be maintained either in flexion or in extension, but it is rarely in the exact degree of flexion assumed for ease in a true joint-inflammation, and the position is apt to be changed from day to day or from hour to hour. The skin is usually pale and cool, but may be red and hot, because of hyperemia. A periodically developed heat may be observed, especially at night, accompanied apparently by much pain. The alleged pain in some cases is neuralgia, but in most cases is a pain-hallucination. There is no effusion into the joint, and swelling does not exist, although occasionally there is slight periarticular edema. In some rare cases organic disease arises in a hysterical joint.

Hysterical phenomena are seldom isolated, but are associated with certain stigmata which may be latent. These stigmata are concentric contraction of the visual fields, pharyngeal anesthesia, convulsions, hysterogenic zones, globus hystericus, clavicus hystericus, zones of anesthesia, especially hemianesthesia, and hyperesthetic areas. Such patients are predisposed by inheritance, and have previously, as a rule, had nervous troubles. Hysterical phenomena, be it remembered, lack regularity of evolution, and are produced, altered, or abolished by mental influences and physical sensations which are without effect in causing, modifying, or curing organic disease. The general health, as a rule, is good, but neurasthenia may coexist. In examining these patients the observer will note that the symptoms disappear when the attention is diverted; that they are out of all proportion to the local evidences of disease; that there is no sign of joint-destruction; and that a light touch may cause more pain than does firm pressure. If the patient is anesthetized, perfect joint mobility will be found.

Treatment.—The treatment for a hysterical joint comprises attention to the general health, the employment of nourishing and easily digested food, the prevention of constipation, and the administration of tonics if they are needed. The surgeon must dominate his patient's mind and make her realize that he is master of the case. He is to be an inexorable but just ruler—never a brutal or a cruel one. If possible, send the patient away from the harmful sympathies of her home and let her have the rest treatment

of S. Weir Mitchell. Local remedies applied to the joint do harm, as a rule, by concentrating afresh the patient's attention upon the articulation, although the hot iron sometimes does good. Suggestion in the hypnotic state may be tried. The use of morphin should be avoided as being the worst of enemies. Never immobilize the joint, and always use massage, passive motions, and frictions.

Neuralgia of the joints as an independent, isolated affection is extremely rare, though as a complication of other diseases it is by no means uncommon. Neuralgia is more common outside of the joints than in them, and periarticular neuralgia is especially frequent about the knee and the ankle. Joint-neuralgia may arise in any person, but it is more commonly present in young neurotic females. The pain may be persistent, or it may occur in periodic storms, and it is often associated with neuralgia in other parts. The pain may be dull and aching, but it is more often sharp and shooting. Joint-neuralgia is associated with tenderness on pressure, soreness on motion, often with transitory swelling without redness, and sometimes with numbness of the extremities. The *diagnosis* depends on the temperament of the patient, the sudden onset of the pain, the absence of constitutional symptoms, and the free mobility of the joint, especially under ether. Articular neuralgia may depend upon disease or injury of the central nervous system, upon malaria, syphilis, neurasthenia, rheumatism, gout, hysteria, and neuritis, and may be due to reflected irritation, especially from the ovaries, the uterus, or the rectum.

Treatment.—The treatment to be observed in joint-neuralgia is to maintain the general health. Examine for a possible exciting cause, and, if found, remove it. Give a long course of iron, quinin, and strychnin or arsenic. In rheumatic or gouty subjects administer suitable drugs and insist upon the use of a proper diet. During the attack use phenacetin. Morphin must occasionally be given in severe cases, but be careful of it, and never tell the patients they are taking it, as there is a possibility of their forming the opium-habit. Locally, employ frictions, ointment of aconite, heat, and keep upon the part a piece of flannel soaked in a mixture of soap liniment, laudanum, and chloroform (Gross). Never allow the joint to stiffen; any tendency to stiffness should be met by daily massage, frictions, passive motion, and hot and cold douches. In some rare cases nerve-stretching or neurectomy becomes necessary.

Articular Wounds and Injuries.—A *penetrating* wound is very serious, and it may be due to a compound fracture, to a compound dislocation, to a gunshot-wound, or to a stab. If a bursa near a joint be injured, secondary penetration may occur as a result of suppuration. In a penetrating wound, besides pain, hemorrhage, and swelling, there is a flow of synovial fluid. A small amount of synovia flows from an injured bursa, a large amount from an open joint.

Treatment.—If a joint is opened aseptically (as when incised by the surgeon), the wound heals nicely under rest and antisepsis. If a joint is opened by a septic body, suppurative arthritis is apt to arise, and the surgeon endeavors to prevent it by asepticizing the surface, irrigating the joint, draining, applying antiseptic dressing, and securing rest. Normal salt solution is the best agent for irrigation, as it does not injure joint-endothelium. Active antiseptics are apt to lessen tissue-resistance, and thus may actually favor

infection. In gunshot-wounds inflicted by pistol bullets or sporting rifle bullets, if antisepsis is not employed, suppuration is inevitable; hence military surgeons in the past, as a rule, have advocated amputation or excision in gunshot-splinterings of large joints. Recent experience shows that the wound of a large joint produced by a hard-jacketed and small-caliber bullet may heal with little trouble. In articular wounds the surface is sterilized, and usually the wound is enlarged, the finger is introduced to discover and remove foreign bodies, through-and-through drainage is secured, a tube is inserted, the joint is irrigated, antiseptic dressings are applied, and the extremity is placed upon a splint. Very severe joint-injuries demand resection or even amputation. Ankylosis, more or less complete, often follows a gunshot-wound of a joint. If the joint suppurates, the drainage must be made more free, sinuses must be slit up and packed, sloughs must be cut away, dead bone must be gouged out, and the patient must be placed upon a stimulant and tonic plan of treatment. The above remarks do not apply to wounds inflicted with the modern military projectile. Such wounds are not of necessity infected, and recovery may be prompt and uneventful if the surface is sterilized and antiseptic dressings and splints are applied.

Sprains.—A sprain is a joint-wrench due to a sudden twist or traction, the ligaments being pulled upon or lacerated and the surrounding parts being more or less damaged. A sprain is often a self-reduced dislocation (Douglas Graham). The joints most liable to sprains are the knee, the elbow, and the ankle. The smaller joints are also often sprained, but the ball-and-socket joints are infrequently sprained, their normal range of free movement saving them; they do occasionally suffer severely, however, as a result of abduction. In a bad sprain the ligaments are torn; the synovial membrane is contused or crushed; cartilages are loosened or separated; hemorrhage takes place into and about the joint; muscles and tendons are stretched, displaced, or lacerated; vessels and nerves are damaged; the skin is often contused; and portions of bone or cartilage may be detached from their proper habitat, though still adhering to a ligament or tendon (sprain-fractures). Sprains are commonest in young persons and in adults with weak muscles. They happen from sudden twists and movements when the muscles are relaxed. A large part of the support of joints comes from muscles, and when they are suddenly caught unawares they do not properly support the joint, and a sprain results. A joint once sprained is very liable to a repetition of the damage from slight force. Sprains are common in a limb with weak muscles, in a deformed extremity in which the muscles act in unnatural lines, and in a joint with relaxed ligaments.

Symptoms.—There is severe pain in the joint, accompanied by general weakness. Nausea, vomiting, and even syncope may occur. There is impairment or loss of ability to move the joint. The above-described condition is succeeded by a season of relief from pain while at rest, numbness being complained of, and pain on motion being severe. Swelling arises very early if much blood is effused. In any case swelling begins in a few hours. Extensive effusion, by separating joint-surfaces, produces slight lengthening of the limb. Movements of the joint become difficult or impossible; the tear in the ligament may sometimes be distinctly detected by the examining fingers; pain and tenderness become intense; joint-crepitus will be manifested; and in a day or two

discoloration becomes marked. Moullin and others have pointed out that when a muscle is strained the skin above it becomes sensitive, especially at tendinous insertions over joints. As muscles are invariably strained when a joint is sprained, there is always some cutaneous tenderness. There is also tenderness over a sprained joint due to capsular injury, bands of adhesions, etc. Tenderness is apt to arise at certain reasonably fixed points: in a hip-joint injury it is found behind the great trochanter, in a knee-joint injury by the side of the patella, in an ankle-joint injury to the inner side of the external malleolus (Culp). When the vertebral articulations are sprained, the muscles of the back are rigid, the skin is often sensitive, pain may be awakened by pressure or by certain movements, but there is no sign of cord injury in an uncomplicated case.

Diagnosis and Prognosis.—Sprain-fractures can be diagnosticated with certainty only by the x-rays. In the *diagnosis* of a sprain, fracture and dislocation must be considered. In fracture, crepitus and mobility exist; in dis-

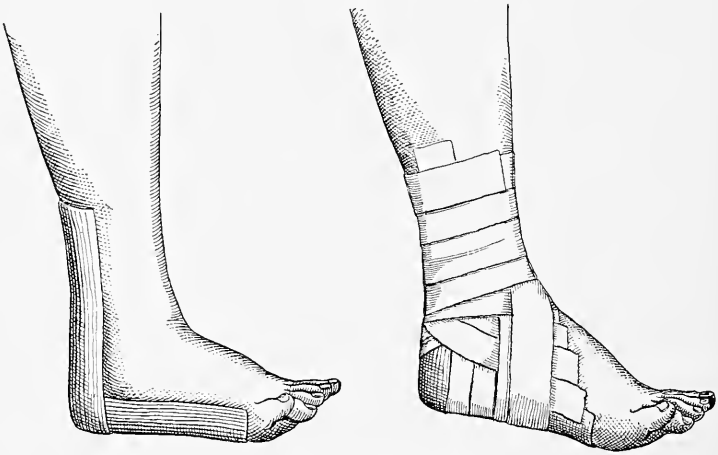


Fig. 298.—Gibney's method of strapping in sprains of the ankle.

location, rigidity. The diagnosis of sprain should be made by a consideration of the joint involved, of the age, of the nature of the force, of the length of the limb, of the fact that the patient could use the joint for at least a short time after the accident, and of the local feel and movements of the part. In some cases examine under ether, in some apply the x-rays. Many injuries about the ankle which we would have formerly regarded as sprains, are often shown by the x-rays to be fractures. The *prognosis* depends on the size of the joint, on the extent of laceration, on the amount of intra-articular hemorrhage, and on the age of the patient. The danger is ankylosis. In rare cases after a sprain of the hip-joint osteo-arthritis arises. In some few cases after a sprain of the hip the head of the bone undergoes absorption.

Treatment.—In a mild sprain apply at once a silicate or plaster-of-Paris dressing. The first indication after the infliction of a severe sprain is to arrest hemorrhage and limit inflammation. For the first few hours apply pressure and an ice-bag. Wrap the joint in absorbent cotton wet with iced water, apply a wet

gauze bandage, and put on an ice-bag. After some hours place the extremity upon a splint and to the joint apply flannel kept wet with lead-water and laudanum, iced water, tincture of arnica, alcohol and water, or a solution of chlorid of ammonium. These evaporating lotions produce cold. Instead of them, an ice-bag may be used for a day or two. Leeches around the joint do good. Constitutionally, employ the remedies for inflammation. Morphin or Dover's powder is given for the pain. Judicious bandaging limits the swelling.

After a day or two, if the symptoms continue or if they grow worse, use hot fomentations, the hot-water bag, plunge the extremity frequently in very hot water, or apply heat by Leiter's tubes. When the acute symptoms begin to subside, rub stimulating liniments upon the joint once or twice a day and employ firm compression by means of a bandage of flannel or rubber. Frictions should be made from the periphery toward the body. Many cases do well at this stage under the local use of ichthyol and lanolin (50 per cent.), tincture of iodin, or blue ointment. Later in the case use hot and cold douches, massage, frictions, passive motion, and the bandage. Passive motion is begun a day or so after swelling ceases. If massage causes the swelling to return, abandon it for several days and then try it again. Blisters are used when tender spots persist and stiffness is manifest. If stiffness becomes marked, move the joint forcibly. Give iodid of potassium and tonics internally, and insist on open-air exercise. If the person is gouty or rheumatic, use appropriate remedies. Van Arsdale treats sprains by massage almost from the start. Gibney treats them by strapping with adhesive plaster. Gibney's dressing is of great service in a sprain of the ankle (Fig. 298). Many sprains may be put up in an immovable dressing the first day or two after the accident. If the joint contains much blood, aspiration should be practised before the dressing is applied.

The hot-air oven is a very valuable method for treating recent sprains, and the swelling, pain, and stiffness which follow sprains, of the extremities. The sprained extremity is placed in an oven, and the part is subjected to heat for an hour. The next day the treatment is repeated, and on as many subsequent days as may be necessary. In an acute sprain the pain often disappears during the first application of heat. In the intervals between the use of the oven the extremity should be at rest upon a splint.

Ankylosis.—When a joint-inflammation eventuates in the formation of new tissue in and about the joint, contraction of this tissue limits or destroys joint-mobility, producing the condition known as "ankylosis." Ankylosis may be complete (bony) or incomplete (fibrous); it may arise from contractures in the joint (true or intra-articular ankylosis) or from contractures in the structures external to the joint (false or extra-articular ankylosis).

True or **intra-articular ankylosis** may arise from any cause which produces joint-inflammation with formation of new tissue, and may be due to wounds, contusions, sprains, dislocations, fractures in or near a joint, movable bodies in a joint, tubercle, gout, rheumatism, or syphilis. Proper immobilization of a healthy joint may cause some stiffness, but not ankylosis. Dr. O. W. Phelps* points out that experiments made by himself in association with Dr. W. Gilman Thompson and Dr. J. C. Cardwell show that immobilization of a normal joint will not produce ankylosis in five months, and that when a

* Railway Surgeon, July 26, 1898.

healthy joint becomes ankylosed, it is due to some pathological cause. Improper immobilization may produce and maintain intra-articular pressure, and such pressure may destroy the head of the bone and the socket, and ankylosis will result. Further, Phelps shows that muscular atrophy is sure to follow prolonged immobilization. Even a proper immobilization of a healthy joint will, if prolonged, cause muscular atrophy, but the weakness and stiffness will pass away entirely under the influence of proper treatment. Firm immobilization with pressure may produce disastrous results. Ankylosis is more apt to take place in a hinge-joint than in a ball-and-socket joint. In ankylosis from a general cause (as rheumatic gout) many joints are apt to suffer. Ankylosis may be due to fibrous change in the synovial membrane, and is then usually partial. The fibrous synovial membrane of one surface may adhere to the other surface of a joint, only small parts of a joint surface may exhibit fibrosis (*limited adhesions*), or the entire joint surface may be bound up in them (*diffused* or *general adhesions*). Ankylosis may be due to chondrification of areas of synovial fibrosis, the synovial membrane having disappeared, and is then incomplete; it may be due to ossification of the fibrous tissue which has replaced synovial membrane, both synovial membrane and cartilage having disappeared (Murphy, "Jour. Am. Med. Assoc.," May 20–27, June 3, 1905), and is then complete, the joint being entirely immobile (*osseous* or *bony ankylosis*). The entire joint may be converted into bone. In what is known as spondylitis deformans there is bony ankylosis of the vertebræ. *Arthritis ossificans* is a progressive bony ankylosis in which numerous joints are involved and are finally completely obliterated. It is essentially the same disease as spondylitis ossificans and is an ossifying arthritis.*

Fibrous ankylosis may follow aseptic inflammation. *Bony ankylosis* is usually the result of an infection. Though slight motion is usually possible in fibrous ankylosis, in some cases it may be impossible. A joint immovable from fibrous ankylosis is distinguished from a joint immovable from bony ankylosis by the fact that in the former attempts at motion are productive of pain, and subsequently of inflammation. The incapacity resulting from ankylosis is due, first, to the impairment or destruction of joint-function, and, secondly, to the fixation at an inconvenient angle (a fixed flexed knee is worse than a fixed extended knee; a fixed extended elbow is worse than a fixed partly flexed elbow).

Treatment.—The effort should always be made to prevent ankylosis by treating carefully any joint-inflammation and by beginning passive motion and massage at the proper time. To limit inflammation is to prevent ankylosis. As a result of inflammation an exudate exists in and about the tendons and ligaments, and even in the joint. Early massage and gentle movements remove this exudate before it is organized, and if organization of the exudate does not occur, ankylosis will not follow the injury or disease. In an acutely inflamed joint, however, passive motions ought not to be made: the part should be kept at rest until acute symptoms subside, but gentle massage can be used daily. When there is recent and limited fibrous ankylosis, it may be improved or cured by the use of the hot-air oven, passive motion, active movements, massage, frictions with stimulating liniments, inunctions of ichthyol or

*See Dr. Joseph Griffith, in Jour. of Pathology and Bacteriology for December, 1896, and March and June, 1897.

mercurial ointment, hot and cold douches, and electricity. Some cases may be straightened out slowly by screw-splints. Fibrous ankylosis of the elbow is best treated by using the joint. The usual treatment of severe fibrous ankylosis is forcible movement after anesthetization to free adhesions and repeated movements to prevent renewed fixation. This may succeed when adhesions run here and there from one synovial surface to the other, but almost always fails when the entire joint-surfaces are adherent. It is bound to fail in osseous or cartilaginous union. Many surgeons, if the tendons are much contracted, perform tenotomy two or three days before forcible straightening is attempted. Suppose a case of extensive fibrous ankylosis of the knee; the usual custom is: administer ether, put the patient upon his back, bring the leg over the end of the operating-table, grasp the ankle with one hand and the lower portion of the leg with the other hand, and make strong, steady movements of flexion and extension until the limb can be straightened. The adhesion will be felt to break, the snapping often being audible. At once apply a plaster-of-Paris dressing to the extended extremity, and keep the limb immobile for two weeks. At the end of this period remove the plaster and begin massage and passive movements, and, if reaction is not great, soon advise active movements, the patient walking about. This violent procedure is not free from danger. Vessels may be ruptured, nerves may be torn, skin and fascia may be lacerated, suppuration may ensue from the admission into the joint of encapsuled cocci or of bacteria from the blood or lymph, which find in this area a *point of least resistance*. Because of the danger of opening up depots of encapsuled bacilli and cocci it is never proper forcibly to break up an ankylosis that results from tuberculous or septic arthritis, the custom in such cases being to use gradual extension by weights or by screw-splints. Ankylosis of the knee following fracture of the patella is almost sure to recur after forcible breaking up and so is extensive fibrous ankylosis. In bony ankylosis of any joint other than the elbow-joint the rule is to do nothing if the joint is in a useful position. If the joint is firmly fixed in an unfortunate position, the surgeon resorts to excision or osteotomy. In the elbow excision should be performed, no matter what the position, in the hope of obtaining a movable joint. In ankylosis of the jaw surgeons formerly endeavored to remedy the condition by wedging the jaws apart with a mouth-gag, and afterward inserting boxwood plugs at frequent intervals. This method is invariably a failure.* Esmarch's operation (removal of a wedge-shaped piece of bone) is sometimes curative. Some operators excise the condyle and a portion of the neck. Swain advocates sawing the bone at the angle. Murphy and Hugier have of late taught us to treat ankylosis on an entirely different plan. Murphy shows that the above methods usually fail.

In cases of synovitis with adhesions he resects the capsule and replaces it by aponeurosis or muscle, and it is desirable, when possible, that the replacing piece contains fat, which, under pressure, will form a hygroma or artificial synovial cavity. In bony ankylosis he operates, separates the bones, removes adjacent bony prominences or processes, frees the soft parts, prevents the bones coming again in contact, and interposes between them tissue which will remain fibrous or will form a hygroma or artificial synovial surface. After wound healing has taken place, passive motion, active motion, and forcible extension are required.

* Swain, in Lancet, 1894, vol. ii, p. 187.

For the details of these operations see the comprehensive article by John B. Murphy on "Ankylosis" ("Jour. Am. Med. Assoc.," May 20–27 and June 3, 1905), and Traitement des Ankyloses par la Résection Orthopédique et L'interposition Musculaire par Le Dr. Alphonse Hugier.

False or Extra-articular Ankylosis.—In this condition the joint is intact, but the contractures are in surrounding parts. The causes are muscular, fascial, and tendinous contractures, cicatrices (especially from burns), deposits of bone, muscular paralyses, tumors, and aneurysms. Contractions of muscles or tendons may be due to gout, rheumatism, injury, thecitis, fractures, and dislocations. False ankylosis is seen in club-foot and in Dupuytren's contraction.

Treatment.—The treatment of false ankylosis depends upon the case. Recently contracted muscles or tendons require motion, massage, frictions with stimulating liniments, hot and cold douches, and the use of the hot-air apparatus. Violent breaking up is not satisfactory, neither is tenotomy or myotomy. Old contractions of tendons require tendon lengthening by tendoplasty or myoplasty (Murphy). Chronic inflammation of tendon-sheaths with adhesion of tendons requires excision of the sheaths (Murphy). Whenever possible, excise a cicatrix that causes false ankylosis, and fill the gap with sound cutaneous tissue and fat. When the fixation is due to adhesive synovitis of the capsule, excise the capsule and attached ligaments; "the head and neck of the bone should then be surrounded by an aponeurosis or muscle to prevent the reforming of adhesions" (John B. Murphy, in "Jour. Am. Med. Assoc.," May 20–27 and June 3, 1905). Bony deposits are gouged away and tumors are removed. Contractures in cases of paralysis require electricity, passive motion, frictions with stimulating liniments, the hot-air bath, and general treatment.

Loose Bodies in Joints (Floating Cartilages).—The knee is the joint affected in 90 per cent. of cases, but the elbow, shoulder, hip, wrist, lower jaw, and ankle may suffer. There may be but one loose body in a joint, there may be two or more, there may be many or even hundreds. More than one joint may be involved. The condition is commonest in adult men. These bodies may be free or each may have a stalk or pedicle; they may move about and occasionally block the joint, or may lie quietly in a joint-recess or diverticulum. They may be flat or ovoid, smooth or irregular, as small as peas or as large as plums, and may be composed of fibrous tissue, of cartilage, or of bone. There are numerous different modes of origin of these bodies, many being "detached ecchondroses or pieces of hyaline cartilage hanging by narrow pedicles" (J. Bland-Sutton), and they result from enlargement and chondrification of the villi of the synovial membrane. Some loose bodies are broken-off osteophytes; some arise from blood-clots; some by projection or herniation of the synovial membrane, which protrusion is broken off; others are detached fringes of tuberculous synovial membrane. Traumatism is supposed to be a usual exciting cause, but in many cases there is no history of traumatism. Some believe that an injury may separate a bit of articular cartilage, but others deny this. An old injury, perhaps a forgotten injury, may have been the cause, not by directly breaking off a bit of cartilage, but by damaging it so that it undergoes necrosis and eventually separates. It is certain that pathological changes in a joint may be the cause,

and that a body which has given no evidence of its presence may begin to give rise to symptoms after a twist of or a blow upon the joint.

Symptoms.—Many bodies give rise to no symptoms for a long time and others merely cause synovitis. A loose body may produce pain and interfere with joint-function. The joint is weak and a little swollen, and the patient can perhaps feel the body and often can push it into a superficial area of the joint, where it may be felt by the surgeon. From time to time the body may get caught, thus suddenly locking the joint and producing intense and sickening pain, extension and flexion being impossible until the body slips out. It may slip out in a moment, but may not for hours or even for many days. A rather small body seems more apt to cause locking than a very large one, but if a large one does cause locking, it is more difficult to dislodge than is a small one. Locking of a joint by a loose body is followed by inflammation and effusion. If the loose body is dense or long, the x-ray may disclose it. In some cases of loose body in the knee the diagnosis is impossible from dislocation of a semilunar cartilage, inflamed semilunar, and synovitis with proliferation of villi.

Treatment.—To relieve locking, employ forced flexion and sudden extension. Cure can be obtained only by operation. Let the patient bring the foreign body to a point where it can be felt by the surgeon, so that he can determine where it lodges. Asepticize the knee with the utmost care. Operate if possible under cocain; if not, give ether. If the body is felt before operating, fix it with a pin. The joint is now opened, the foreign body extracted, and an exploration made to see that no other bodies are present. The wound is sutured and the leg is placed upon a splint. Asepsis must be most rigid. The operation does not cure the causative lesion, and these bodies are apt to form again. When the knee is involved, some surgeons saw the patella transversely, open the joint widely, remove all foreign bodies, and seek to cure any causative lesion.

Luxation or Dislocations.

A dislocation is the persistent separation from each other, partially or completely, of two articular surfaces. A self-reduced dislocation is called a sprain (Douglas Graham). There are three forms of dislocations: (1) traumatic; (2) spontaneous or pathological; (3) congenital.

1. Traumatic dislocations are due to injury. They are divided into—*complete* dislocation, in which the two articular surfaces are entirely separated and the ligaments are torn; *incomplete* or *partial* dislocation or *subluxation*, in which the two articular surfaces are not completely separated and the ligaments are rarely lacerated; *simple* dislocations, in which there is no wound leading from the surface to the articulation; *compound* dislocation, in which a wound leads from the surface to the joint; *complicated* dislocation, in which, besides the dislocation, there is a fracture, extensive damage of the soft parts, an opening which makes the case compound, or damage of a nerve or blood-vessel; *primitive* or *primary* dislocation, in which the bones remain as originally displaced; *secondary* dislocation, in which the dislocated bone assumes a new position; for instance, a subglenoid luxation of the humerus is primary, and it may become secondarily a subcoracoid luxation because of muscular contraction or attempts at reduction; *recent* dislocation, in which

the displaced bone is not firmly fastened by tissue-changes in its new situation, and its old socket is not obliterated; *old* dislocation, in which the displaced bone is firmly fastened by tissue-changes in its new habitat, and the old socket is to a great extent obliterated (whether a dislocation is old or new depends on the state of the parts rather than on the time which has elapsed since the accident); *double* dislocation, in which corresponding bones on each side are dislocated; *single* dislocation, in which only one joint is dislocated; *unilateral* dislocation, in which one articulation of one bone is out of place; *bilateral* dislocation, in which symmetrical articulations are dislocated; and *relapsing* or *habitual* dislocation, which recurs constantly from slight force because of relaxed ligaments or lack of complete repair after the ligamentous rupture of a first dislocation.

2. Spontaneous, Pathological, or Consecutive Dislocations.—Spontaneous dislocation arises from such very slight force that the cause may not be identified, and it acts on a joint rendered lax by disease. It may arise in the course of chronic synovitis, tuberculous joint-disease, or rheumatoid arthritis. In Charcot's joint a spontaneous dislocation will occur sooner or later. In typhoid fever spontaneous dislocation is not uncommon. The hip-joint is most often the one attacked. *Dislocation in typhoid fever* generally occurs at the hip-joint, follows a severe joint inflammation, is usually upon the dorsum of the ilium, and is frequently not noticed until convalescence has set in. If a typhoid dislocation is seen early, reduction is easily effected, but if seen late, is impossible. The treatment for irreducible typhoid dislocation is the same as for any other irreducible dislocation.

3. Congenital Dislocation.—A congenital dislocation is due to a congenital joint-malformation which renders it impossible for the bone to maintain a normal position, or is due to external violence during the period of uterine gestation. Congenital dislocations should not be confounded with dislocations produced during delivery. The hip is the joint most often involved. The shoulder suffers occasionally. Lannelongue maintains that congenital dislocation of the hip is due to atrophy of the muscles and of the acetabulum following spinal-cord disease. Verneuil thinks the dislocation is paralytic. Broca says that in view of the fact that the head of the bone is larger than the cavity in which it belongs, it is useless to attempt reduction by manipulation or extension. Lorenz and Hoffa have each devised an operation for this condition (pages 635, 636). Congenital dislocation of the shoulder requires incision, possibly excision, or the paring down of the head to fit the glenoid cavity (Phelps).

Traumatic Dislocations.—In the succeeding pages the traumatic form of dislocations will be particularly considered.

The **causes** of traumatic dislocations are divided into *predisposing* and *exciting*.

Predisposing causes are: (1) *age;* dislocations are commonest in middle life, the usual lesion of the young being green-stick fracture, and that of the old being fracture; dislocations of the radius are not uncommon in youth; (2) *muscular development*, dislocations being commonest in those with powerful muscles; (3) *sex*, males being more predisposed than females, because of their occupations and muscular strength; (4) *occupation* predisposes as a cause according as it demands the employment of muscular force, as in the carrying

of burdens; (5) *nature of the joint*, ball-and-socket joints being more liable to luxation than are ginglymoid joints, because of their wide range of motion; (6) *joint-disease* predisposes by relaxing the ligaments; (7) *situation of the joint*, some joints being more exposed to injury than others.

Exciting causes are divided into—(1) external violence and (2) muscular action. *External violence* may be *direct*, as when a blow upon one of the bones forces it directly away from the other; or it may be *indirect*, as when a blow at a distant part of a bone transmits force to its end and drives the bone out of its socket. *Muscular action* is a cause when sudden and violent muscular contraction occurs during the maintenance of a position of the joint which gives the muscles full sway, and throws the head of the bone against the weakest part of its retaining ligaments.

Pathological Conditions.—In a recent complete traumatic dislocation the ligaments are damaged, and may perhaps show extensive laceration, or may show only a buttonhole laceration through which a bone projects. External force produces much laceration and little stretching of the ligaments; muscular action produces little laceration and much stretching of the ligaments. In some cases of dislocation due to external violence the structures about the joint are bruised or otherwise damaged; the old socket is filled with blood, and the bone in its new situation lies in a bloody area. Large vessels and nerves are rarely torn, though they may be compressed.

If a dislocation is not soon reduced, inflammation arises in the old joint and about the displaced bone, and the whole area is glued together, first by coagulated exudate, and finally by fibrous tissue. After a time, in ball-and-socket joints, the old socket fills with fibrous tissue, contracts, becomes irregular, and may even be obliterated; the head of the dislocated bone is altered in shape, its cartilage is destroyed or converted into fibrous tissue, and the pressure of the head of the bone forms a hollow in its new situation, which hollow becomes surrounded by fibrous tissue or even by bone. A new joint may form, the surrounding tissue becoming a compact capsule, and a bursa forming between the head of the bone and its new socket. In a dislocated hinge-joint the ends of the bone alter greatly in shape and their cartilage is converted into fibrous tissue. In an unreduced dislocation the muscles shorten or lengthen or undergo atrophy or fatty degeneration, as the case may be. An unreduced dislocation of a ball-and-socket joint may give a fairly movable new joint, but an unreduced dislocation of a hinge-joint rarely allows of much motion.

General Symptoms of Traumatic Dislocation.—In general, traumatic dislocations are indicated—(1) by *pain* of a sickening, nauseating character; (2) by *rigidity*, voluntary motion being impossible except to a slight extent in the direction of the deformity. (For instance, in dislocation of the inferior maxillary the jaw can be opened a little more, but it cannot be closed.) This rigidity brings about loss of function. When the surgeon attempts to move the joint he finds it very rigid; (3) by *change in the shape of the joint* (as flattening of the shoulder after dislocation of the humerus); (4) by *alteration in the mutual relations of bony prominences about a joint* (as the alteration of the relation between the olecranon and humeral condyles in dislocation of the elbow backward); (5) by feeling the displaced bone in its new situation; (6) by missing the head of the bone from its proper situation; (7) by alteration

in the length of the limb (in dislocation of the femur into the thyroid foramen the limb is lengthened, but in dislocation onto the dorsum of the ilium it is shortened); and (8) by alteration in the axis of the bone (in dislocation upon the dorsum of the ilium the axis of the injured thigh would, if prolonged, pass through the lower third of the sound thigh); (9) by seeing the dislocation with a fluoroscope or looking at a skiagraph of it.

Diagnosis of Traumatic Dislocation.—A dislocation may be mistaken for a fracture. In dislocation there is rigidity, in fracture there is preternatural mobility; in dislocation there is no true crepitus (may get tendon- or joint-crepitus), in fracture there usually is crepitus; in dislocation the deformity does not tend to recur after reduction, in fracture it does recur after extension is relaxed. In a sprain the movements of the joint are only limited, not abolished, by the almost complete rigidity encountered in dislocation. The change which a sprain may cause in the shape of a joint is due to effusion or to bleeding; there is no alteration in the relation of the bony prominences to one another; there is no notable alteration in the length of the limb (a slight increase in length may arise from joint-effusion, or the head of the bone may subsequently be absorbed and thus produce shortening after some weeks); there is no alteration in the axis of the bone; the bony head is not felt in a new position, and it is found in its normal place. Always remember that a fracture may exist with a dislocation. In any doubtful case—in fact, in most cases—give ether, for a dislocation should be reduced while the patient is anesthetized (except in dislocation of the jaw, of the fingers, of the carpus, etc.). In some cases swelling renders the diagnosis difficult or impossible. Always compare the injured joint with the corresponding joint of the sound side. The *x*-rays constitute a valuable aid to diagnosis.

Treatment of Traumatic Dislocations.—*Recent Simple Dislocations.*—Reduce simple dislocations under ether, as a rule. Try *manipulation*, a procedure which seeks to make the bone retrace its own pathway. If this procedure fails, employ extension and counter-extension. If considerable force is needed, an assistant makes counter-extension, and the surgeon fastens to the extremity a clove-hitch, which he ties about his waist, and thus secures powerful extension. Counter-extension may be obtained by bands, or, in some instances, by the foot of the surgeon. The *clove-hitch* is used because it will not tighten by traction; a tightening band would lacerate the soft parts (Fig. 304). If great power is needed, compound pulleys may be employed, such as the Jarvis adjuster or some similar appliance, but at the present day pulleys are rarely used (see page 592). If these means fail, cut down upon the bone and restore it to position; operation is much safer than is the application of great force. After reducing a dislocation, immobilize the joint for a time, which varies for different joints, and for the first few days combat swelling and inflammation by rest of the part and the use of evaporating lotions or an ice-bag. If there exists a fracture of the dislocated bone, apply splints and then try to reduce by manipulations, grasping the limb and the splints with one hand below and, if possible, with the other hand above the seat of the fracture. Allis believes that a dislocation can be reduced even when a fracture exists. It is possible to pull the dislocated head down to the joint, because a portion of periosteum and possibly tendinous material and muscle still hold the two fragments as a strap might unite two sticks. The head can

be forced into place by the fingers while traction is being made. If the fracture is near the joint and the fragments cannot be fixed, try to reduce the dislocation, first striving to press the bone into place. This attempt can be greatly aided by traction upon the lower fragment. In some cases with fracture reduction can be much aided by making a small incision, screwing a gimlet into the head of the bone, and using this tool as a handle. McBurney incises, drills a hole in each bone, inserts hooks into them, and pulls the dislocated bone into position (Figs. 210, 211, and 212). When the dislocation has been reduced, the bone fragments should be wired together.

Compound Traumatic Dislocations.—The opening in the soft parts may be due to external violence or to projection of a bone. Compound dislocations are very serious. Hinge-joints are more liable to these injuries than are ball-and-socket joints. Many cases require excision: some, amputation; one that does not demand excision or amputation should be treated by sterilizing the parts, restoring the dislocated bone, making a counter-opening, draining, dressing antiseptically, and immobilizing. Considerable ankylosis generally ensues, except sometimes in the small joints. It is scarcely ever necessary to cut away any portion of the protruding bone to effect reduction. If a joint is badly splintered, or if the soft parts are extensively damaged, it may be necessary to excise or amputate; if the main vessels of a limb are seriously injured, amputation must be considered. If the patient is so old or so feeble that it is perilous to force him to combat a long illness, amputation should be performed.

Old Traumatic Dislocations.—The problem always presented in an old dislocation is, Shall reduction be tried or shall the bones be let alone? Sir Astley Cooper laid down this rule: "Do not attempt to reduce a shoulder-dislocation after three months, nor a hip-dislocation after two months"; but this rule was put forth before the days of ether. Do not select any fixed period of time to determine what action is advisable. In dislocation of a ball-and-socket joint considerable motion may become possible and a new joint may form. If movement does not produce pain, a useful new joint may be obtained by the persistent employment of active and passive movements; if movement of the limb does produce pain, enough motion will not be attempted by the patient to produce a useful joint. In the former case it may be best to try to obtain a useful new joint, and in the latter case the surgeon should endeavor to reduce the old dislocation. Always remember that dislocation of a hinge-joint, if left unreduced, will never eventuate in a useful new joint.

In trying to reduce an old dislocation give ether, make movement to break up adhesions, and persist in making these motions until the head of the bone is felt to move; then try at once to reduce by manipulation or extension and counter-extension, not waiting for two days, as some suggest. If the head of the bone cannot be made to move, the Dieffenbach plan has been advised, which is to cut the tense restraining bands with a tenotome. Lord Lister, being much impressed with the danger inevitably linked with forcibly dragging old dislocations into place, prefers to cut down and restore the bone, employing, of course, the strictest asepsis, and surgeons in general have adopted this view. In some old dislocations excision of the head of the bone is the proper operation.

Special Traumatic Dislocations.—Lower Jaw.—A dislocation of the lower jaw, when there is no fracture, is almost invariably forward.

Backward dislocation without fracture is extremely rare, and some have maintained that it cannot occur. Croker King reported a case in 1858. Theim has observed it seven times in five women. The condyle passes under the lower surface of the auditory canal.* The common dislocation is forward, and this is the form meant when we simply speak of dislocation of the jaw. There are two forms of forward dislocation—the *unilateral*, which is rare, and the *bilateral*, which is common. Dislocations of the jaw are commonest in women and during middle life. When the mouth is open, contraction of the external pterygoid muscle may pull the condyle over the articular eminence; this contraction may be brought about by yawning, vomiting, scolding, etc. When the mouth is open, dislocation of the lower jaw may be caused by a blow upon the chin; it may also be caused by forcing the mouth more widely open by pushing a bulky body between the teeth.

Symptoms of Lower-jaw Dislocations.—In the *bilateral* form the mouth is open and fixed, and it cannot be closed, though it can be opened a little more. The condyles are in front of the articular eminences, and are fixed by the action of the masseters and internal pterygoids, the coronoid processes being wedged against the malar bones. The lower jaw is advanced in front of the upper jaw and the face looks longer than natural. The lips cannot close, the saliva dribbles, swallowing and speech are difficult, there is a depression in front of each ear, the condyles are recognizable in their new abodes, the coronoid processes are detected by a finger in the mouth, and the masseters and temporals stand out in a state of rigidity. Pain may be severe, may be moderate, or may be absent. In the *unilateral* form the chin goes toward the sound side, and the mouth is not so widely open as in the bilateral form, neither is the jaw so fixed. The symptoms are similar to those of a bilateral luxation, but are not so pronounced. The hollow in front of the ear and the abnormal situation of the condyle are detected upon one side only. In an unreduced dislocation the patient may after a time establish some movement of the jaw, but the power of mastication will always be seriously impaired.

Treatment of Lower-jaw Dislocations.—In reducing a dislocation of the lower jaw the patient is placed with his head against the back of a chair or against the body of an assistant. The surgeon, after wrapping up his thumbs to protect them from being bitten, stands in front of the patient, puts his thumbs upon the last molar teeth, and grasps the chin with his free fingers. He now presses downward and backward on the jaw, and as soon as the condyle is loosened, closes the jaw over the thumbs by pushing up the chin, using his thumbs as levers. If this procedure fails, wedges should be put between the molar teeth and the chin should be pushed up either by the hands or by a tourniquet whose band is round the head and chin. In a unilateral dislocation the wedge should be used only on the injured side. In difficult cases Sir Astley Cooper pushed a round wooden ruler between the molar teeth, used the upper teeth as a fulcrum, and raised the end of the ruler as the handle of a lever. The forceps used by an anesthetist may depress the condyle from its point of fixation, whereupon the chin may be pushed up and back. Nélaton advises that the surgeon place his thumbs in the mouth of the patient and push the coronoid processes backward. After reduction a Barton bandage should be applied and worn for over two weeks. The dressing should be renewed once a day, and passive motion

* Theim, in Rev. de Chir., vol. viii, 1888.

is to be begun in the second week. The bandage may be discarded at the end of the third week. Liquid diet is advisable for three weeks after the accident. In an old dislocation reduction is always attempted, at least up to a period of six or seven months after the accident. An irreducible dislocation requires osteotomy of the neck of the bone if the part cannot be restored after incision.

Dislocation of the Clavicle.—Sternal End.—There are three forms of dislocation of the sternal end of the clavicle, namely: (1) forward; (2) backward; and (3) upward.

Forward Dislocation of the Sternal End of the Clavicle.—The *causes* of forward dislocation of the clavicle are blows, falls, or pulls which drive or draw the shoulder backward.

Symptoms and Treatment of Forward Dislocation of the Sternal End of the Clavicle.—The symptoms manifest in dislocation of the clavicle are:

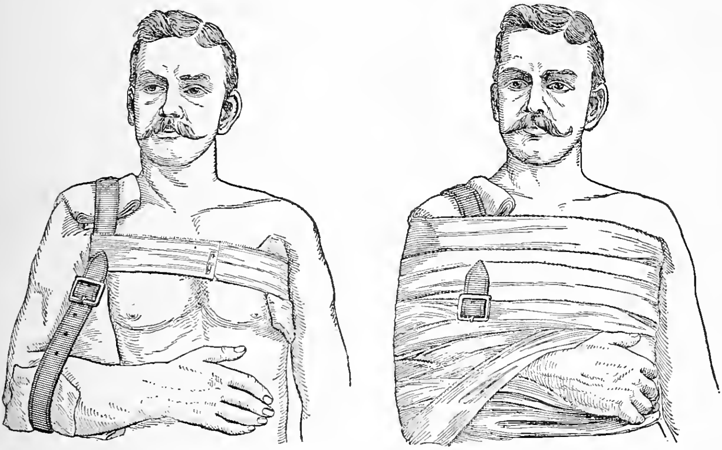


Fig. 299.—Rhoads's apparatus for treating dislocation upward of the acromial end of the clavicle.

prominence in front of the sternum; the acromion is nearer to the sternum on the injured than on the sound side; the clavicular origin of the sternocleidomastoid muscle is rigid; movement is difficult and painful. To reduce a dislocation of the clavicle, pull the shoulders back against the knee of the surgeon, which is placed between the scapulæ. Dress with a posterior figure-of-eight bandage (Fig. 667) or a Velpeau bandage (Fig. 669), the dressing to be worn for three weeks. After removal of the dressing apply a truss, the pad of which is put over the head of the clavicle, and which instrument is to be worn for a month. Dislocation of the clavicle is difficult to keep reduced, but even if it becomes fixed in deformity, the motions of the arm will not be impaired permanently. It can be reduced and fixed by incision and wiring.

Backward dislocation of the sternal end of the clavicle is very rare. The *causes* are direct violence and indirect force, such as falls or blows which drive the shoulder forward and inward.

Symptoms and Treatment of Backward Dislocation of the Sternal End of the Clavicle.—The symptoms are: pain; loss of function in the arm; inclination of head toward the injured side; stiffness of the neck; the shoulder passes

forward and inward, and often falls downward; a depression exists over the sternoclavicular joint; the head of the clavicle cannot be felt, or is found back of the sternum. The displaced clavicle may press upon the trachea, the esophagus, or the great vessels, inducing dyspnea, dysphagia, obliteration of pulse in the arm of the injured side, or great venous congestion of the head (see Pick). The usual method of treatment is to pull the shoulders backward and apply a posterior figure-of-eight bandage (Fig. 667), which must be worn for three weeks. If pressure-symptoms are urgent, it is the rule to incise, restore the bone to place and wire it, or resect the displaced head.

Upward dislocation of a clavicle is very rare. The *cause* is indirect force which carries the shoulder downward, inward, and backward (Smith).

Symptoms and Treatment of Upward Dislocation of the Sternal End of the Clavicle.—The chief symptom is impaired function of the arm; the shoulder passes downward and inward, the clavicular axis is altered, and the displaced head is felt. Dyspnea may or may not exist. To treat this dislocation, put a pad in the axilla and press the elbow to the side in order to throw the bone outward, and try to push the head into place. Apply a Desault bandage (Fig. 671) and place a firm pad over the sternoclavicular joint. The deformity is apt to recur, but a useful limb will nevertheless be obtained. The best method of treatment is to wire the bones in place.

Dislocation of the acromial end of the clavicle is almost always upward, but it may be below the acromion. The *cause* is violent force, which, if so applied to the scapula as to drive the shoulder forward, may produce a dislocation upward. A dislocation downward is due to blows upon the upper surface of the outer end of the clavicle.

Symptoms and Treatment.—In dislocation of the acromial end of the clavicle upward there are noted: prominence of the clavicle upon the top of the acromion; impaired function of the arm (it cannot be lifted over the head); the shoulder falls downward and passes inward; there is apparent lengthening of the arm; the head is bent toward the injured side, and the clavicular origin of the trapezius is strongly outlined (Pick). In *dislocation downward* both the acromion and the coracoid are very prominent, the clavicular axis is altered, and there is depression over the sternoclavicular joint. The surgeon usually endeavors to reduce a dislocation upward by placing the patient supine on a hard table, pulling the shoulder back, and pushing the bone into place. After reduction the old method of treatment was to apply a Desault bandage, which was kept on for three weeks, and decided deformity, enduring pain, and disability were looked for as inevitable. Stimson used to apply dressings of adhesive plaster. The author has seen one case treated by the apparatus of Thomas Leidy Rhoads. The apparatus completely corrected the deformity, and the patient made a most satisfactory recovery. The essential element of Rhoads's apparatus is a trunk-strap applied as is shown in Fig. 299. If the deformity can be completely corrected, Rhoads's apparatus will serve a good purpose, but in many cases it is impossible really to reduce the deformity or after apparent reduction the deformity at once returns. This is due, as Moore points out ("Annals of Surgery," May, 1902) to the fact that the superior acromioclavicular ligament is torn from the clavicle but remains attached to the scapula, and when reduction is attempted, is pushed under the clavicle and nothing remains to hold the clavicle "in place

but the skin and superficial fascia." I agree with Moore that the best treatment is incision, replacement, and suturing the acromion to the outer end of the clavicle. The bones are sutured with silver wire or kangaroo tendon, the acromioclavicular ligament is sutured with catgut, the wound is closed with sutures of silkworm gut, and the patient is kept supine in bed for three weeks. I have operated successfully on two of these cases. Dislocation downward is reduced and treated in the same manner as dislocation upward.

Simultaneous dislocation of both ends of the clavicle is a very rare injury. It is treated as is single dislocation.

The so-called **dislocation of the lower angle of the scapula** is not, as was long taught, a dislocation at all. The lower angle and vertebral border deviate from the chest. This condition was thought to be due to the bone slipping from under the latissimus dorsi muscle, but it is now known to be due to *paralysis* of the *serratus magnus muscle*, the bone being acted upon by the trapezius, pectoralis minor, levator anguli scapulæ, and rhomboid muscles. Examination shows that the scapula will not rotate normally forward. This is demonstrated by extending the arms in front to a right angle, the gliding forward of the scapula upon the sound side being marked and upon the diseased side being slight or absent.

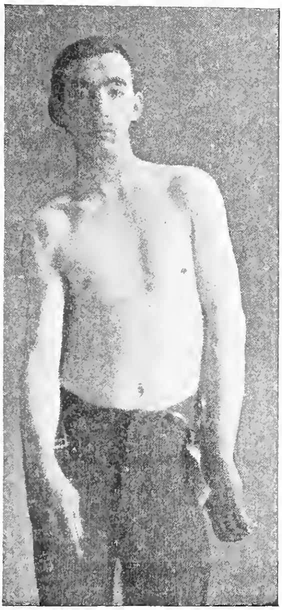


Fig. 300.—Axillary dislocation of the right humerus.

Treatment of paralysis of the serratus magnus muscle comprises massage, electricity, passive motion, and deep injections of strychnin.

Dislocations of the Humerus (**Shoulder-joint**).—These injuries are quite frequent because of the free mobility of the shoulder-joint, its anatomical insecurity, and its exposed situation; they rarely occur in the very young and in the aged, and are oftenest encountered in muscular young adults. Four chief forms of shoulder-joint dislocation exist, namely: (1) forward, inward, and downward, under the coracoid process—subcoracoid; (2) downward, forward, and inward, beneath the glenoid cavity—subglenoid; (3) backward, inward, and downward, under the spine of the scapula—subspinous; and (4) forward, inward, and upward, under the clavicle—subclavicular.

A very rare form of shoulder-joint dislocation has been described, which is known as the *supracoracoid*. Another rare form is the *luxatio erecta*.

Subcoracoid Luxation.—The subcoracoid variety of dislocation embraces three-fourths of all the shoulder-joint luxations. It may be caused by direct force driving the head of the humerus forward and inward, or by indirect force, such as falls upon the hand or the elbow. In this dislocation the head of the bone lies against the anterior surface of the scapular neck below the coracoid process. A part of the anatomical neck of the humerus lies upon the anterior margin of the glenoid cavity, and the head of the bone is above the tendon of the subscapularis muscle.

Subclavicular Luxation.—Is very rare. It is caused by the same sort of

violence which produces subcoracoid luxation. The head of the bone rests upon the thorax, below the clavicle, and underneath the pectoralis major muscle.

Subglenoid or Axillary Luxation (Fig. 300).—May be produced by contraction of the great pectoral and latissimus dorsi muscles when the arm is at a right angle to the body, but it is usually due to falls upon the hand or the elbow when the arm is raised and the head of the bone is against the lower portion of the capsule. In this dislocation the head of the bone rests upon the border of the scapula, below the tendon of the subscapularis, in front of the long head of the triceps, and above the teres muscles. Some observers hold that most dislocations of the shoulder are primarily subglenoid, the position having been altered by muscular action. *Luxatio erecta* is an unusual

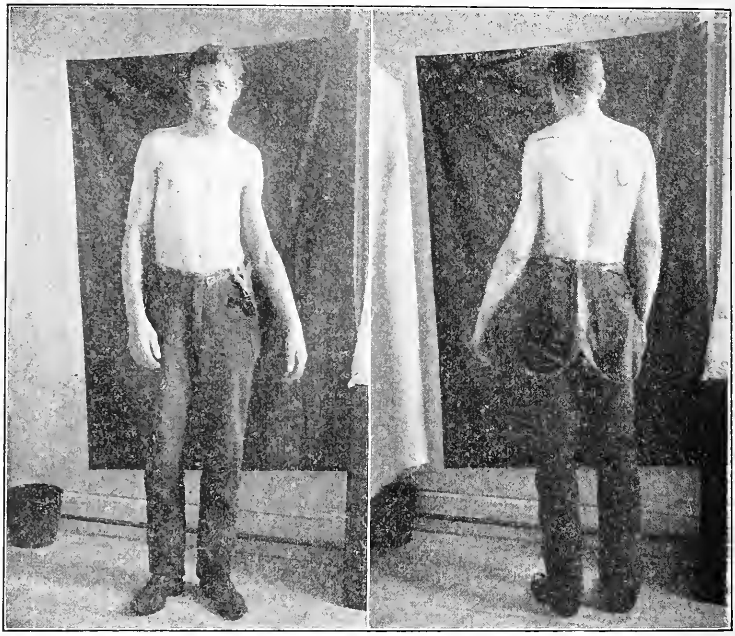


Fig. 301.—Subcoracoid dislocation of the left humerus (St. Joseph's Hospital case; photographed by Dr. Nassau).

form of subglenoid dislocation. The arm is upright and the forearm rests behind the occiput or on the top of the head, and the patient holds it there to avoid pain. Judd, Hulke, and Cleland have related cases.

Subspinous Luxation.—Is a rare injury. Pick met with this accident in a man who, while having his hands in his pockets, fell upon the front of the point of the shoulder. The head of the bone reposes beneath the scapular spine, between the infraspinatus and teres minor muscles.

Supracoracoid luxation is seldom encountered. The head of the humerus rests upon the coraco-acromial ligament or upon the acromion process, and the acromion or the coracoid is always fractured.

Symptoms of Dislocation of the Shoulder-joint.—Dislocation is diagnosticated by—(1) pain of a sickening character; (2) flattening of the shoulder,

the head of the bone having ceased to bulge out the deltoid muscle; (3) apparent projection of the acromion through sinking in of the deltoid; (4) hollow beneath the acromion, over the empty glenoid cavity, and the bone missed from its normal habitat. This hollow may be easily appreciated by the finger, especially when the extremity is somewhat abducted; (5) rigidity (some movement is possible, in the direction especially of an existing deformity, but mobility is strictly limited and attempts at motion produce great pain); (6) Dugas's sign: the elbow cannot touch the side when the hand is placed upon the sound shoulder, and the hand cannot be placed upon the sound shoulder if the elbow is to the side (this is due to the rotundity of the chest. In a dislocation the head of the bone is already touching the chest, and the bone, being approximately straight, cannot touch it in two places at the same time. If the elbow can be placed against the chest with the hand on the sound shoulder, there cannot be dislocation; if it cannot be so placed, there must be dislocation); (7) finding the head of the bone in a new situation; (8) examining by means of the x-rays. Symptoms 1 to 5 inclusive may be grouped as Erichsen's list of signs. The form of dislocation is made out by a study of the direction of the axis of the limb, the existence and extent of lengthening or of shortening, and the situation of the head of the bone.

In a shoulder-joint dislocation the head of the bone may press upon the brachial plexus and produce pain and numbness, and occasionally traumatic neuritis or paralysis; sometimes pressure upon the axillary vein causes intense edema, and pressure upon the axillary artery diminishes or obliterates the pulse. The axillary vessels may be torn and the muscles may be lacerated badly. The capsule is torn and considerable blood is usually effused. Swelling is due first to hemorrhage, and secondly to inflammation. Partial dislocations sometimes, though rarely, occur. What is usually spoken of as "partial dislocation" or "subluxation" is a condition in which the head of the humerus passes forward under the coracoid because of rupture of the long head of the biceps or because this tendon slips out of its groove, the ligaments of the shoulder-joint being intact.

The following table from T. Pickering Pick's work on "Fractures and Dislocations" makes the above points clear:

	Direction of the Axis of the Limb.	Alteration in the Length of the Limb.	Presence of the Head of the Bone in New Situation.
Subcoracoid.	The elbow is carried backward and slightly away from the side.	Very slight lengthening.	The head of the bone cannot easily be felt; it is found at the upper and inner part of the axilla.
Subglenoid.	The elbow is carried away from the trunk and slightly backward.	Very considerable lengthening.	The head of the bone can easily be felt in the axilla.
Subspinous.	The elbow is raised from the side and carried forward.	Lengthening intermediate in degree between the subglenoid and the subcoracoid.	The head of the bone can be felt and be grasped beneath the spine of the scapula.
Subclavicular.	The elbow is carried outward and backward.	Shortening.	The head of the bone can readily be seen and be felt beneath the clavicle.

Diagnosis of Shoulder-joint Dislocation.—In *fracture of the neck of the scapula* the acromion is prominent, a hollow is detected below it, and a hard body is felt in the axilla; but the coracoid process descends with the head of the humerus, which it does not do in dislocation. Furthermore, in fracture there is mobility; in dislocation, rigidity. In fracture crepitus is present; in dislocation it is absent. In fracture the deformity is easily reduced, but it at once recurs; in dislocation the deformity is with difficulty reduced, but does not recur. In fracture the elbow can be made to touch the side when the hand is upon the sound shoulder; in dislocation it cannot be so manipulated. In *fracture* of the *anatomical neck of the humerus* deformity is slight; the head of the humerus is found in place, does not move when the shaft is rotated, and is not in line with the axis of the bone. Crepitus exists in the fracture if impaction is absent. In *paralysis of the deltoid muscle* there is distinct flattening, but the bone is felt in place and there is no rigidity. The *x*-rays are a great aid to diagnosis.

Treatment of Shoulder-joint Dislocation.—Reduction by manipulation is usually readily obtained in recent cases of shoulder-joint dislocation. If a simple trial without ether fails, an anesthetic should be administered. Ether is given but not chloroform, for chloroform seems to be particularly dangerous to life when given to enable the surgeon to reduce a dislocation of the shoulder. *Forward dislocations* (subcoracoid, subclavicular, and axillary) are reduced by *Kocher's method* (Fig. 302). Reduction by this method can frequently be effected without the aid of ether. Put the elbow against the side, and flex the forearm upon the arm, raise the elbow, make external rotation, and thus carry the head of the humerus to the margin of the glenoid cavity. If there is much muscular resistance, follow Keetley's advice, and not only bring the elbow to the side, but push it backward and inward toward the spine. External rotation is then begun. External rotation must be done slowly and gently. When we first try it there is much muscular resistance. If enough force is used to overcome the resistance, the surgical neck of the bone may be broken. By gently and gradually persisting in external rotation, the muscles are finally tired out. External rotation serves to relax the untorn portion of the capsule. Next lift the elbow anteriorly to bring the head of the humerus of the glenoid margin just opposite the capsular tear (Keetley). Then throw the bone into place by internal rotation. The formula is, flexion of the forearm, external rotation, lifting the elbow forward, internal rotation of the arm, and lowering the elbow. The motions to unlock the bone and start it to retrace the steps it took when emerging should be gentle, not forcible, slow, not sudden; and rigid muscles should be tired out and made to relax by steady traction upon them. Sudden and violent motions increase rigidity. If in trying Kocher's plan external rotation of the humerus does not take place, abandon the method, as persistence will fracture the humerus. Another method of manipulation is as follows: if the *right* shoulder is dislocated, the surgeon stands behind the patient (who is sitting erect); if the *left* shoulder is dislocated, he stands in front of the patient. The surgeon holds the forearm flexed upon the arm with his right hand and makes external traction and rotation, and with the fingers of his left hand he tries to force the bone into place.

In *Henry H. Smith's method* for forward dislocations the surgeon stands

in front of the patient. If the *left* shoulder is dislocated, the surgeon grasps it with his left hand; if the *right* shoulder is dislocated, he grasps it with his right hand, the thumb resting on the head of the bone. With his disengaged hand the surgeon grasps the elbow, abducts it, makes traction and external rotation, and suddenly sweeps the elbow inward, aiming it at the sternum, and tries with his thumb to push the bone into place. In *subspinous luxations* reduction may be effected if the surgeon stands behind the patient, makes abduction, traction, and internal rotation, sweeps the elbow inward toward the spine, and with the thumb aids the bone in its return into position. Raising the elbow far above the head and sweeping it inward will reduce some dislocations. As the head of the bone slips back a distinct jar is felt and a snap is heard, the motions of the joint are again obtainable, and with the hand on the opposite shoulder the elbow may be made to touch the side.

Reduction by Extension.—Before attempting the reduction of a dislocation of the shoulder-joint by extension, the patient should be anesthetized and placed upon a low bed or upon the floor. The surgeon then places

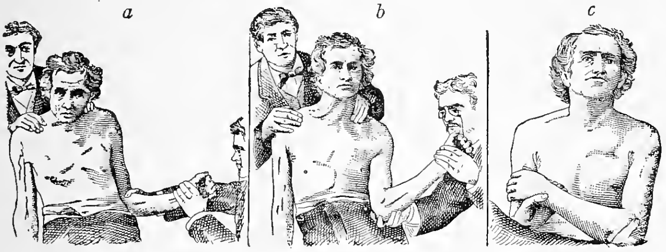


Fig. 302.—Kocher's method of reduction by manipulation; *a*, First movement, outward rotation; *b*, second movement, elevation of elbow; *c*, third movement, inward rotation and lowering of the elbow (Ceppi).

his foot, covered only by a stocking, in the axilla. Place the sole of the foot, not the heel, against the chest high up, the instep being made to touch the humerus and the heel the border of the shoulder-blade, a towel being first put into the axilla to rest the foot against (Fig. 303). If the left arm is dislocated, use the left foot, and *vice versâ*. The elder Gross approved of making extension while sitting between the patient's limbs. Make steady extension, which will in many cases bring about the reduction. If it fails to cause reduction, bring the patient's arm across the chest and use the foot as the fulcrum of a lever. If the humerus is pretty firmly fixed in its abnormal position, make counter-extension with a foot in the axilla and make extension by fixing a clove-hitch (Fig. 304) *above the elbow* and fastening to it bands which go over one shoulder and under the other shoulder of the surgeon. The back may thus be used for extension, the hands being left free for manipulation (Allis's and Pick's plan). Lateral extension is used by some surgeons. The patient lies down, a large piece of canvas is split, the arm is passed through the split, and the body is thus fixed. The arm is pulled to a right angle with the body and traction is applied.

The late Prof. Joseph Pancoast favored *Sir Astley Cooper's method* of

placing the unanesthetized patient in a chair and using the knee as a fulcrum, pushing the elbow to the side (Fig. 305). Brunus, in the thirteenth century, devised the method of *upward extension.* In applying this method the

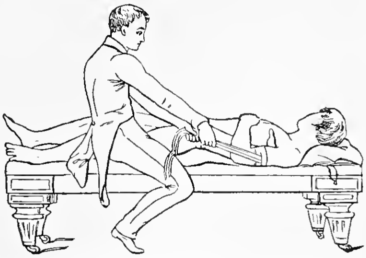


Fig. 303.—Reduction of shoulder-joint dislocation by the foot in the axilla (Cooper).

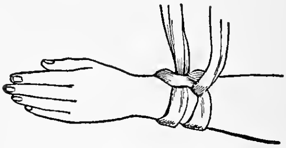


Fig. 304.—Clove-hitch knot applied above the wrist. In dislocation of the shoulder this knot is put above the elbow (after Erichsen).

surgeon takes his place behind the patient, steadies the scapula with his hand, and carries the patient's arm upward and backward above his head, making extension and external rotation (Fig. 306). *La Mothe's method* is applied with the patient supine upon the floor. The surgeon places his foot upon the shoulder to make counter-extension, and makes extension as in Brunus's method. It is a useful expedient, when either of these plans is applied, to have an assistant make the traction while the surgeon manipulates the head of the bone. Cock advises, when reduction fails, that an air-pad be placed in the axilla

Fig. 305.—Reduction of shoulder-joint dislocation by the knee in the axilla (Cooper).

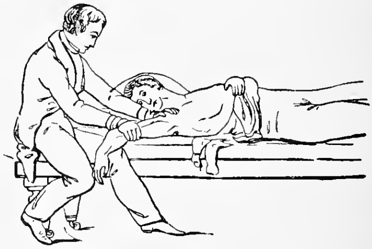


Fig. 306.—Reduction of shoulder-joint dislocation by upward extension (Cooper).

and the arm be bound to the side—a method by which reduction will sometimes take place after two or three days.

Pulleys should not be used to pull the bone into place, as they develop a dangerous force. In a dislocation irreducible by ordinary force, antiseptic incision is safer and better than the pulleys. After incision try to restore the bone to place.

In reducing a dislocation the axillary artery or vein may be ruptured, fracture of the neck of the humerus may take place, injury to the brachial plexus may occur, or the soft parts may be badly damaged. After reducing a dislocation apply a Velpeau bandage, keep the shoulder immobile for one week, then make passive motion daily, reapplying the dressing after each séance. The patient may wear a sling alone during the third week, after which period he may use the arm. (For compound dislocations see page 583.)

Old Dislocations of the Shoulder.—In some cases where we find there is considerable movement without pain we can, by manipulation and active motion, seek to increase the range of movement and usefulness of the new joint.

As a rule, in a youth or a middle-aged person we attempt bloodless reduction if we see the case by or before the ninetieth day after the accident. Give ether, break up adhesions by forced flexion and extension, and try Kocher's method, and, if this fails, the other methods, but never use violent force. In reducing an old dislocation we may fracture the surgical neck of the humerus. I have seen this happen twice. The proper treatment is incision and pulling the head into place with McBurney's hooks. In attempting reduction of an old dislocation the brachial plexus may be lacerated or one or both of the axillary vessels may be torn. If an axillary vessel is torn, it must be at once exposed by incision. A large tear in either vessel requires a ligature about the vessel on each side of the tear. A small tear may be sutured (Keetley, in "Lancet," Jan. 23, 1904). Rather than use sufficient force to endanger the vessels in attempting to reduce an old dislocation, practise incision. In some cases after incision the head of the bone can be pulled into place. In other cases the head must be resected. After reduction of an old dislocation immobilize for three weeks, and begin passive motion after seven days.

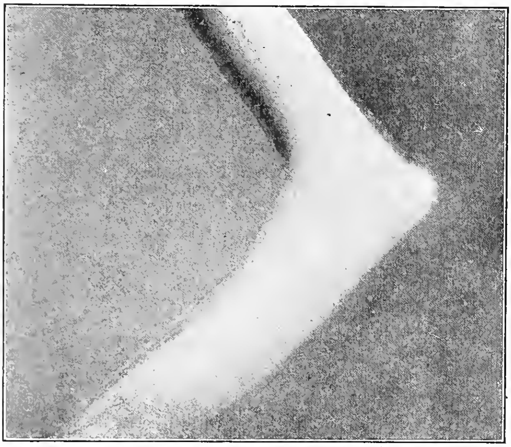


Fig. 307.—Dislocation of both bones of the forearm backward.

If a *dislocation* is *complicated* by a *fracture of the humerus*, try to pull the head of the bone opposite the joint. This may be possible if the two fragments are held partly together by a fair amount of periosteum and muscle, Traction is exerted upon the arm, and an attempt is made to manipulate the head into the socket (Allis's plan in the hip). McBurney incises, fixes a hook in the scapula and a hook in the head of the humerus, pulls the head into place, and wires the fragments (Figs. 210, 211, 212). In an emergency gimlets may be used instead of the hooks. In some cases it is necessary to excise the head of the bone.

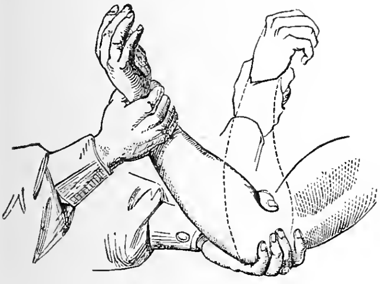


Fig. 308.—Reduction of elbow-joint dislocation.

Dislocations of the Elbow-joint.—Dislocations of the elbow-joint are not infrequent, and they are commonest in children. Both bones or only one

bone of the forearm may be dislocated, and the dislocation may be partial or complete.

Dislocation of Both Bones Backward.—The *causes* of backward dislocation of both bones of the forearm are falls upon the extended hand or twists inward of the ulna (Malgaigne). The coronoid process lodges in the olecranon fossa of the humerus.

Symptoms of Backward Dislocation.—In complete dislocation of both bones of the forearm the olecranon is very prominent (Fig. 307). The distance between the point of the olecranon and the apex of the inner condyle is notably greater than on the sound side; the forearm is flexed, supinated, and shortened; the lower end of the humerus projects in front of the joint, below the skin-crease; the head of the radius is found back of the outer condyle; and there are the general symptoms of dislocation. Fracture of the coronoid rarely occurs with backward dislocation, but if it does occur, there will be crepitus and mobility. Fracture at the base of the condyles is distinguished from dislocation of both bones of the forearm backward by the following points: in fracture there are found the ordinary symptoms; measurement from the

Fig. 309.—Forward dislocation of the radius.

condyles to the styloid processes does not show shortening; there is no alteration of the normal relation between the olecranon process and the condyles; and the projection in front of the joint is above the crease of the bend of the elbow.

Treatment of Backward Dislocation.—Reduction must be effected early in dislocation of both bones of the forearm, because it will soon become impossible, and an unreduced dislocation means a limb without the powers of flexion, pronation, and supination. The surgeon may place his knee in front of the elbow-joint, grasp the patient's wrist, press upon the radius and ulna with his knee, and bend the forearm with considerable force, the muscle pulling the bones into place (Sir Astley Cooper's plan). Forced flexion, traction, and extension may be tried (Fig. 308). Put the arm in Jones's position for two weeks, and make passive motion daily after the first few days.

Dislocation of Both Bones Forward.—The *cause* of forward dislocation of both bones of the forearm is a blow on the olecranon when the arm is flexed. It is an unusual accident.

Symptoms and Treatment.—The symptoms of forward dislocation of both bones of the forearm are—the forearm is flexed and lengthened; some slight motion is possible; the olecranon is on a level with the condyles if unfractured,

hence its prominence is gone; the humeral condyles are felt posteriorly, and the radius and ulna are felt anteriorly. The *treatment* of this injury consists in early reduction, which is accomplished by means of forced flexion, extension, and pressure, placing the part in Jones's position for two weeks, and making passive motion daily after the first few days.

Lateral dislocation of both bones of the forearm is usually incomplete.

Symptoms and Treatment of Outward Dislocation.—The symptoms of outward dislocation of both bones of the forearm are—the forearm is flexed, fixed, and pronated; the joint is widened; the head of the radius projects externally and has a depression above it; the inner condyle projects internally and has a depression below it; the olecranon is nearer than normal to the external condyle and further than normal from the internal condyle. Reduction is effected by extension of the forearm and pressure inward upon the head of the radius. Apply an ascending spiral reversed bandage of the forearm, a figure-of-eight bandage of the elbow-joint, and a sling. Make passive motion after a few days. The bandages must be worn for two weeks.

Symptoms and Treatment of Inward Dislocation.—In dislocation inward of both bones of the forearm the position of the forearm is the same as that in dislocation outward; the sigmoid cavity of the ulna projects internally, and the external condyle projects externally. Reduction is effected by extension of the forearm and pressure outward on the ulna, subsequent treatment being the same as that employed in the preceding form.

Dislocation of the ulna alone is very rare, and can take place only backward.

Symptoms and Treatment.—Dislocation of the ulna alone is indicated by the forearm being flexed and pronated. The head of the radius is found in place, and the olecranon projects posteriorly. The *treatment* of this injury is the same as that for dislocation of both bones.

Dislocation of the Radius Forward (Fig. 309).—Dislocation of the radius forward is the commonest form of dislocation of the elbow. This injury is caused by a fall upon the hand with the forearm in pronation and extension, or is produced by blows on the back of the joint; forced pronation alone will not cause it.

Symptoms and Treatment.—The symptoms in dislocation of the radius forward are—the forearm is midway between pronation and supination, and is semiflexed; attempts to increase flexion cause the radius to strike against the humerus with a distinct blow; the head of the radius is felt in front of the outer condyle and is missed from its proper abode. Reduction is effected by flexion over the knee, extension, and manipulation. The subsequent treatment is Jones's position and passive motion. Deformity is apt to recur after reduction, because of rupture of the orbicular ligament.

Dislocation of the radius backward is caused by falls on the hand or by blows on the front of the joint.

Symptoms and Treatment.—Backward dislocation of the radius is indicated by the forearm being slightly flexed and fixed in pronation, by some impairment of flexion and extension, and by the head of the radius being felt behind the outer condyle. Reduction is effected by flexion over the knee, extension, and manipulation, and the subsequent treatment is the same as that given for the preceding dislocation.

Dislocation of the radius outward is very rare. In this injury the head of the radius is distinctly felt. Reduction is effected by extension and pressure; the subsequent treatment is the same as that for the above-mentioned dislocations.

Subluxation of the Head of the Radius.—This name is given to an injury which is very frequent in children between two and four years of age. It results from traction upon the hand or the forearm, and often arises when the nurse or the mother pulls upon a child's arm to save it from a fall or to lift it over a gutter. Some writers hold that pronation as well as extension is required to produce the injury; many surgeons claim that extension and adduction are the causative forces. Hutchinson asserts that supination may cause subluxation. Bardenheuer assigned falls as causes.

The *symptoms* are very characteristic. The history points to the injury. Pain, and often a click, may be felt in the wrist at the time of the accident. The arm hangs by the side, with the elbow-joint slightly flexed and the forearm midway between pronation and supination. Flexion to an angle of less than 60° and complete extension are resisted and are very painful, but movements between 60° and 130° are free and painless.* The movements of the wrist-joint are free and painless. The elbow-joint presents no deformity. Pressure over the head of the radius causes pain. Strong pronation is painful; strong supination is very painful, and there seems to be a mechanical obstacle to its performance. Forced supination develops a distinct click at the head of the radius, and causes pronation and supination to become natural and free from pain. The condition will be reproduced if the parts are not immobilized for a time. The nature of the lesion is not understood, and various conditions have been thought to exist by different observers. Among them may be mentioned the following: a slight anterior displacement of a head of the radius; a slight posterior displacement; locking of the tuberosity of the radius behind the inner edge of the ulna; dislocation of the triangular cartilage of the wrist; intracapsular fracture of the radial head; painful paralysis from nerve-injury; displacement by elongation, the return of the bone being prevented by collapse of the capsule; and the slipping up of the margin of the orbicular ligament over the rim of the head of the radius.

Treatment.—In order to reduce place the forearm at a right angle to the arm and make forcible supination. Apply an anterior angular splint, and have it worn for four or five days, or put the part in Jones's position for an equal period.

Dislocations of the wrist are very uncommon and are caused by falls upon the hand.

Backward Dislocation of the Wrist.—*Symptoms.*—The deformity in backward dislocation of the wrist (Fig. 310, A) resembles that of Colles's fracture (Fig. 310, B). The fingers are flexed, the wrist is bent backward, the radius projects on the front of the wrist, the carpus projects on the dorsal surface of the forearm, the relation of the styloid process of the radius to the styloid process of the ulna is unaltered (it is altered in Colles's fracture), there is rigidity, and crepitus is absent.

Forward dislocation of the wrist, which is very unusual, is caused by a fall upon the back of the hand.

* See the instructive article by W. W. Van Arsdale, in the Annals of Surgery, vol. ix, 1889.

Symptoms and Treatment.—In forward dislocation of the wrist the radius and ulna project posteriorly and the carpus projects in front. The *treatment* in both of these dislocations is reduction by extension and manipulation, the use of a Bond splint for ten days, and the employment of passive motion after five or six days.

Dislocation at the inferior radio-ulnar articulation, which is also very common, is caused by twists.

Symptoms and Treatment.—In *forward* dislocation at the inferior radio-ulnar articulation the forearm is pronated, the space between the styloid processes is diminished, and the ulna forms a projection posteriorly. In *backward* dislocation the forearm is supinated, the space between the styloid processes is diminished, and the ulna projects in front. Reduction is accomplished by extension and manipulation. Two straight splints (as in fracture of both bones) are to be applied for four weeks, and passive motion is to be made in the third week.

Dislocation of Individual Carpal Bones.—Pick says there is one weak spot, which is "between the head of the os magnum and the scaphoid and semilunar bones," and the os magnum may be forced up. This lesion is called by some dislocation of the os magnum backward. Codman and Chase

Fig. 310.—Deformity in dislocation of the wrist backward (A) and in Colles's fracture (B) (Stimson).

("Annals of Surgery," March and June, 1905) regard the injury as really *dislocation of the semilunar forward*, a dislocation which may be associated with fracture of the carpal scaphoid. The injury is caused by forcible overextension or by twisting of the wrist. According to Codman and Chase, the injury usually occurs in men between thirty and forty, results from violent force, produces severe pain immediately, and tenderness and ecchymosis quickly arise. On examination a silver-fork deformity is observed, the posterior projection being the os magnum, this projection being separated from the radius by a groove which marks the former situation of the dislocated semilunar. The dislocated bone is felt under the flexor tendons of the wrist, the palm seems shorter than its fellow, the fingers are partly flexed, active or passive motion causes pain, and the x-ray exhibits the dislocated bone ("Annals of Surgery," March and June, 1905).

Treatment.—According to Codman and Chase, recent dislocations (even after the fifth week) may be reduced by hyperextension followed by hyperflexion over "the thumbs of an assistant held firmly in the flexure of the wrist or the semilunar" ("Annals of Surgery," March and June, 1905).

If bloodless reduction fails, the authors advise palmar incision and reduction, and if this fails, excision of the bone. If in excising the semilunar the scaphoid is found to be fractured, the proximal part or the entire scaphoid must also be removed.

Dislocations of metacarpal bones are uncommon. The first metacarpal bone is most liable to dislocation.

Symptoms and Treatment.—Dislocations of the metacarpal bones are obvious because of projection. The dislocations are reduced by extension and manipulation, a straight splint and large pad for the palm are applied (as in fracture of the metacarpus), and the splint is worn for three weeks.

Dislocations at the metacarpophalangeal articulations are uncommon. Backward dislocation is the most common. The *cause* is a fall upon the hand.

Symptoms and Treatment.—Dislocated metacarpophalangeal articulations are obvious. Reduction is easily effected by extension and manipulation, except in the case of the thumb. A splint must be worn for three weeks.

Dislocation of the Metacarpophalangeal Joint of the Thumb.—In this dislocation the phalanx usually passes backward. In some cases the long flexor of the thumb gets to the ulnar side of the head of the metacarpal bone and hinders reduction (J. Hutchinson, Jr., in "Brit. Med. Jour.,"

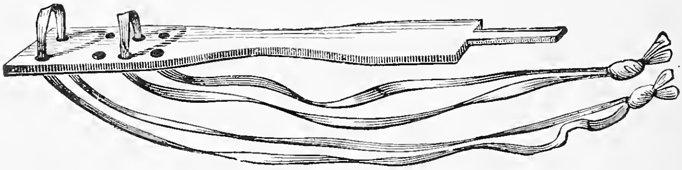


Fig. 311.—Levis's splint for reducing dislocation of phalanges.

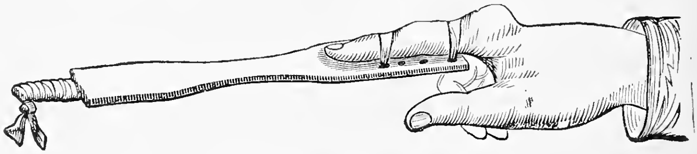


Fig. 312.—Levis's splint applied.

Jan. 15, 1898). The chief impediments to reduction, as demonstrated by Farabeuf, are the sesamoid bones and glenoid ligament, which accompany the base of the phalanx in the dislocation. It is not probable that the catching of the metacarpal bone between the two heads of the flexor brevis, which often happens, is an important impediment.

Symptoms.—The symptoms of *backward* dislocation are as follows: The base of the first phalanx rests upon the metacarpal bone; the head of the metacarpal bone projects forward and buttonholes the muscles of the thumb; the first phalanx of the thumb is strongly extended, and the terminal phalanx is semiflexed. The symptoms of *forward* dislocation are as follows: The base of the first phalanx is felt in the palm, and the head of the metacarpal bone is felt posteriorly.

Treatment.—In treating backward dislocation of the metacarpophalangeal joint of the thumb reduction is difficult. Always give ether. Keetley's directions are to adduct the metacarpal bone into the palm (this relaxes the flexor muscles) and to have an assistant hold it; bend the thumb strongly

back, extend, pull the thumb toward the fingers, and suddenly flex. To get a firm enough grasp for these manipulations use the apparatus of Charrière or of Levis (Figs. 311, 312). If the above maneuvers fail, incise freely on the dorsum and reduce. Tenotomy is seldom of service. After reduction of this dislocation a splint must be worn for three weeks. In forward dislocation reduction is easily effected by strong extension and forced flexion. A splint is to be worn for three weeks.

Dislocations of the phalanges may be complete or may be partial. They are commonest between the first and second phalanges.

Symptoms and Treatment.—Dislocations of the phalanges are obvious. In reducing such dislocations employ extension and manipulation. Use a splint for one week.

Dislocations of the Ribs and Costal Cartilages.—The ribs may be dislocated from the vertebræ. This accident is seldom uncomplicated, and cannot be differentiated from fracture. The diagnosis is rarely made, and the injury is treated as a fracture. The ribs may be dislocated from their cartilages, one or more ribs being displaced. The end of the rib forms an anterior projection, there is a depression over the cartilage, and crepitus is absent. *Treatment* is the same as that employed for fractured ribs. The costal cartilages may be displaced from the sternum, forming an anterior projection upon this bone. Reduction is brought about by placing the patient upon a table, with a sand pillow between the scapulæ, pushing back the shoulders and chest, and forcing the cartilage into place. The dressings are the same as those used in fractured sternum. The cartilages of the lower ribs (sixth, seventh, eighth, ninth, and tenth) may be separated. The inferior cartilage goes forward and can be felt. Pick states that reduction is brought about by causing the patient to hold the chest full of air while efforts are made to push the cartilage into place. The injury is dressed as are fractured ribs (page 476).

Dislocations of the Sternum.—In dislocations of the body of the sternum the manubrium is separated from the gladiolus. The injury is a rare one, is usually associated with fracture, and is most common in the young. It is due in most cases to violent direct force inflicted by a fall or heavy blow; it may be due to indirect force and arose in one case of acute tetanus. The *symptoms* and *treatment* are the same as those of fracture (page 477). Dislocation of the ensiform process is one of the rarest of injuries. It is usually due to direct force, but Polaillon reports a case caused by tight lacing.

Pelvic dislocations are almost always complicated with fracture. A pubic bone can be dislocated by falls from a height or by applying violent force to the acetabula. The dislocation may be up or down, front or back, and it may damage the urethra or the bladder. The patient cannot stand; there are great pain and recognizable deformity. Treat by moulding the bones into place, by applying a pelvic belt, and by rest in bed for four weeks. Dislocations of the sacro-iliac joint are produced by falls. Movement on the part of the patient is difficult or impossible; there is violent pain, and often paralysis (from pressure upon nerves). In dislocation backward there is apparent shortening of the leg, eversion of the foot exists, and the ilium

moves posteriorly and upward. In dislocation forward the anterior superior iliac spine projects and the pelvis is broadened. Sacro-iliac dislocations are reduced by holding the pelvis firm and making extension with a pulley. The patient stays in bed for four weeks and wears a pelvic belt as in fracture.

Dislocations of the Femur (Hip-joint).—These injuries are not often encountered, as the hip-joint is very strong. They occur in young adults. In forcible extension the head of the femur presses against the capsule of the joint, but the capsule here is very thick, and certain muscles, the rectus, psoas, and iliacus, are pulled tight and serve to strengthen it. The head of the bone cannot go directly upward, because of the acetabulum (Edmund Owen). The weak point of the acetabular rim is below; the weak part of the capsule is also below; hence forced abduction is apt to push the head of the bone through the lower part of the capsule, a dislocation occurring primarily into the thyroid foramen. The signs of the dislocation depend upon the untorn portion of the capsule. The Y-ligament and more than the Y-ligament usually escape laceration. Vessels are rarely injured. Muscles are often torn. In some cases the sciatic nerve is lacerated, bruised, or caught up on the neck of the bone. Four forms of hip-joint dislocation are usually described: (1) upward and backward, on the dorsum of the ilium; (2) backward, into the sciatic notch; (3) downward, into the obturator foramen; and (4) inward, on the pubes.

All dislocations are primarily inward or outward. From these initial positions the head may be shifted to any region about the socket within reach of the remnant of untorn capsule (Oscar H. Allis). Allis rejects the old classification and suggests the following:

Low thyroid,
Mid- "
High " } All present abduction and outward rotation.

Reversed thyroid:

Low dorsal,
Mid- "
High " } All present adduction and inward rotation.

Dislocations upon the dorsum of the ilium comprise one-half of all hip-dislocations. They are *caused* by a fall or a blow when the limb is flexed and abducted (as in carrying a weight upon the shoulder), by a fall upon the knees or feet, by a weight striking the back while bending, etc. Allis says rotation inward is the chief element in their production. In these dislocations the head of the femur goes upward and backward, rests upon the ilium, and is always above the tendon of the obturator internus muscle. These dislocations are secondary to thyroid dislocation, muscular action shifting the bone from its initial seat of displacement.

Signs.—Dislocation on to the dorsum of the ilium is indicated by the following symptoms: the buttock appears flat and broad; the great trochanter is above Nélaton's line and is deeply placed; the head of the bone can be detected in its new situation; deep pressure in front of the joints finds a hollow; the leg is shortened by about two or three inches, as a rule; the fascia lata is relaxed; in some thin people the socket can be outlined; when the patient is

recumbent the injured extremity can be brought to the perpendicular without flexing the leg (Allis); the knee is somewhat flexed; the thigh is slightly flexed, inwardly rotated, and adducted (Fig. 313) (this is shown by the fact that the axis of the thigh of the injured side, if prolonged, would pass through the lower third of the sound thigh); when the capsule is extensively lacerated there may be no adduction and may be eversion (Allis); the heel is raised, and the great toe of the foot of the injured side rests upon the front of the instep or the ankle of the sound side; rigidity exists; voluntary movement is impossible, though some passive motion is possible in the direction of the deformity (the deformity can be made more marked). If a patient is recumbent and the knees vertical, the foot of the sound extremity is free of the bed, but the foot of the injured extremity touches the bed (Allis's sign).

Diagnosis.—Examine first without anesthesia, and then again while the patient is anesthetized. The *x*-rays are valuable in diagnosis. Dislocation is distinguished from intracapsular fracture by noting the inversion, the great shortening, the absence of crepitus, the age of the subject, and the nature of the force. The nature of the force, the inversion, and the absence of crepitus mark the diagnosis from extracapsular fracture.

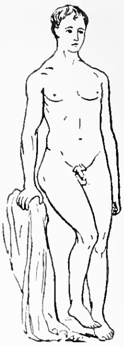


Fig. 313.—Hip-joint dislocation on to the dorsum of the ilium (Cooper).

Treatment.—The chief obstacle to reduction in dislocation on to the dorsum of the ilium, Bigelow states, is the untorn portion of the capsule, especially the Y-ligament. The ilio-femoral, Y, or Bigelow's ligament resembles an inverted Y, arises from the anterior inferior spine of the ilium, is inserted into the anterior intertrochanteric line, and is incorporated into the front of the capsule. To reduce a dislocation this ligament must be relaxed by manipulation or be torn by extension. Manipulation makes the head of the bone retrace its steps over the same route it took in emerging. Give ether; place the patient supine upon a mattress on the floor; flex the leg on the thigh (to relax the hamstrings), flex the thigh on the pelvis; increase the adduction over the middle line; strongly abduct; perform external rotation and extension. This treatment may be summed up as flexion, adduction, external circumduction, and extension; or, as Pick puts it, "bend up, roll out, turn out, and extend." Allis's advice is to fix the pelvis to the floor, lift the head of the bone to the level of the socket, rotate outward by carrying the leg toward the pubis, and extend the femur. If extension and counter-extension are employed, make extension in the axis of the dislocated limb and obtain counter-extension by a perineal band. The extension band is fastened to the thigh by a clove-hitch. After reduction put the patient to bed and use sand-bags (as in fracture of the hip) for four weeks. We may tie the knees together instead of using the sand-bags. Passive motion is made in the third week. The pulleys must not be used in reduction. They may inflict great or even fatal injury. If the surgeon fails to reduce the deformity, there are two courses open to him. He may let it alone. He may operate. If he lets it alone, the limb will become ankylosed, though probably useful. Allis thinks the dorsal region will be the best place to leave it. If he determines to operate, he must recognize that tenotomy is

useless. It is necessary to make a free incision in order to restore the bone.

Dislocation into the Sciatic Notch.—In this dislocation the head of of the bone passes backward and a little upward, and rests upon the ischium at the margin of the sciatic notch (not in the notch), below the tendon of the obturator internus muscle. The *causes* are the same as those given for the previous dislocation.

Signs.—The signs in dislocation into the sciatic notch are like those of dislocation upon the dorsum of the ilium, but they are not so marked. There are flattening and broadening of the hip; ascent of the trochanter above Nélaton's line; shortening to the extent of an inch; relaxation of the fascia lata. If the knee of the injured side is vertical, the sole of the foot touches the bed. Flexion, inward rotation, and adduction exist, but the axis of the femur of the injured side passes through the knee of the sound side, and the ball of the great toe of the injured side rests upon the great toe of the sound side (Fig. 314). Other symptoms are identical with those of dislocation upon the dorsum of the ilium, but are less pronounced. Allis's signs of this dislocation are of value: if, with the patient recumbent, the thighs are brought to a right angle with the body, shortening on the affected side is materially increased; if the dislocated thigh is extended, the back arches as in hip disease.

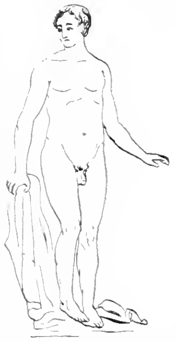


Fig. 314.—Hip-joint dislocation into the sciatic notch (Cooper).

Diagnosis and Treatment.—The signs of dislocation into the sciatic notch are similar to, but are less marked than, those of dorsal dislocation, and, being a backward dislocation, the reduction and treatment are the same as for dislocation backward upon the dorsum of the ilium.

Dislocation Downward into the Obturator Foramen.—Downward dislocation is the primary position of most dislocations of the hip, the bone rarely remaining in the thyroid foramen, but usually mounting up as a result of muscular action or of the initial violence. The *cause* is violent abduction by falls or by stepping from a moving car.

Signs.—Dislocation downward into the obturator foramen is indicated by flattening of the hip; the head of the bone is felt in its new position and is missed from the acetabulum; rigidity exists; passive motion is only possible in the direction of deformity, and that to a slight extent; a hollow is noted over the great trochanter, which process is well below Nélaton's line and nearer than normal to the middle line. The gluteal crease is lower than is the crease of the opposite side; there is lengthening to the extent of one to two inches; the body is bent forward by the traction upon the psoas and iliacus muscles, and is also deviated to the side, thus causing great apparent lengthening; the limb is advanced partially flexed and abducted, and the foot is pointed straight ahead or is a little everted (Fig. 315); when the patient is recumbent, extension is impossible, the knees cannot be pushed together without great pain, and the abductor muscles are hard and rigid. Allis's sign is absent. Unreduced dislocations do well, the patient obtaining a very useful hip-joint (Sédillot).

Treatment.—In treating dislocation downward into the obturator foramen give ether and effect reduction, if possible, by manipulation, and, if this fails, by extension. To reduce by manipulation, flex the leg on the thigh and the thigh on the pelvis, and then perform, in the following order, abduction, internal circumduction, and extension. Allis's rule of reduction is as follows: fix the pelvis to the floor; pull the head of the femur outward and above the socket; fix the head; push the knee toward sound knee and extend the femur. If extension is made, make traction in the axis of the limb by means of muslin fastened around the thigh by a clove-hitch. Do not use pulleys; incise rather than use them.

Fig. 315.—Hip-joint dislocation into the obturator or thyroid foramen (Cooper).

Dislocation upon the pubis is a very uncommon accident. The head of the bone usually rests just internal to the anterior inferior spine of the ilium. The primary position of the bone is in the thyroid foramen; the pubic dislocation, when it occurs, is always secondary, and is due to the initial force and to muscular action.

Symptoms.—In pubic dislocation the head of the bone can be felt and seen in its new position; the hip is flattened; there is a hollow over the great trochanter, this process being found below the anterior superior spine of the ilium; there is shortening to the extent of an inch; the limb is in abduction with eversion (Fig. 316), and the knees cannot be approximated without great pain.

Treatment.—In the treatment of pubic dislocation give ether and employ manipulation as for thyroid dislocation. If this fails, employ extension. The limb is well abducted, extension made downward and backward, and the head of the femur pulled outward "by a towel around the thigh, just beneath the groin" (Keetley). The after-treatment is the same as that for the previous forms.

Fig. 316.—Dislocation on pubis (Cooper).

Anomalous Dislocations of the Hip.—In *supraspinous dislocation* the dislocation of the hip is backward, the head of the femur resting upon the ilium above or even anterior to the anterior superior spine. In *ischial dislocation* the dislocation is downward and backward, the head of the femur resting on the ischial tuberosity or in the lesser sciatic notch. *Monteggia's dislocation* is a supraspinous dislocation with eversion of the limb. In *perineal dislocation* the head of the femur is in the perineum. In *suprapubic dislocation* the head of the femur passes above the pubes. In *subspinous dislocation* the femoral head rests on the horizontal ramus of the pubes.

Dislocation with Catching up of the Sciatic Nerve during Reduction.—This accident causes severe pain. The leg is flexed on the thigh and the thigh is flexed on the pelvis. Allis tells us that the task of reduction is very unpromising. We must strive to put the neck of the femur in such a position that the nerve will "drop off," and yet often the nerve cannot drop off because it is held by adhesion to the injured muscles. Allis attempts reduction by the following plan:

1. Place the patient upon his back and redislocate the femur.

2. Extend the thigh.

3. Flex the leg on the thigh.

4. Turn the ankle out until the leg is horizontal (this causes the head of the bone to look downward).

5. "Shake, shock, jar, adduct, and abduct," to disengage the nerve.

6. Rotate into socket without flexing the leg (without making the nerve tense).

7. If this fails, make an incision above the popliteal space, and draw the nerve out of the wound. Detach the head of the bone from its entanglement and rotate it into the socket.*

Dislocation of the Head of the Femur with Fracture of the Shaft of the Bone.—We may incise and replace and wire the fragments. We may use McBurney's hooks as in the shoulder. We may be forced to do a resection of the head.

Allis maintains that it is possible to reduce it by manipulation. He states that the upper fragment is the entire lever, and the lower fragment "is only the agent through which we apply our force." The fragments are not completely separated, but are connected at one side by material which is "partly periosteal, partly tendinous, and partly muscular." This connecting material enables us to make traction upon the upper fragment, but does not allow "rotation, circumduction, and leverage through the agency of the lower fragment." Hence "the only agency at our command is traction." If the dislocation is inward (forward), draw the head outward and have an assistant make direct pressure upon the head of the bone. If this fails, the assistant holds the head of the bone to prevent its slipping into the thyroid depression, and the surgeon makes traction inward or inward and downward. If the dislocation is outward (backward), make traction directly upward to lift the head of the bone to the level of the socket, and try to place the head over the socket by traction obliquely upward and inward. During all these manipulations an assistant presses upon the trochanter to prevent the head of the bone slipping back. Traction is now made downward and inward, and the tightened ligament drags the head of the bone into place.

Dislocations of the Knee.—These dislocations are rare. There are four forms—forward, backward, inward, and outward. They may be complete or incomplete; the commonest dislocations are lateral. The *cause* is violent force, such as a fall, or in jumping from a moving train, or in being caught by the foot and dragged.

Dislocation Forward of the Knee-joint.—In the *complete* form of forward dislocation the deformity is obvious. The limb is usually extended, but it may be flexed. Much shortening exists; the condyles are felt posterior and below; the head of the tibia is felt anterior and above; the patella is movable and the quadriceps is lax; pressure of the condyles upon the contents of the popliteal space arrests the tibial pulse and causes edema and

* Allis's views will be found in "An Inquiry into the Difficulties Encountered in the Reduction of Dislocations of the Hip." By Oscar H. Allis, M.D. This highly original and valuable treatise received the Samuel D. Gross prize of the Philadelphia Academy of Surgery in 1895.

intense pain. In *incomplete* dislocation the symptoms are identical in kind, but are less pronounced.

Treatment.—Compound dislocation of the knee-joint often demands excision or amputation. In simple dislocation give ether, have one assistant extend the leg while another makes counter-extension on the thigh, and the surgeon pushes the bone into place. Reduction is easy because of ligamentous laceration. Place the limb on a double inclined plane, and combat inflammation by the usual methods (see Synovitis, page 546). Begin passive motion in the third week. The patient must wear a knee-support for months. If the popliteal vessels are much damaged, gangrene will supervene and amputation will be demanded.

Dislocation Backward of the Knee-joint.—In the *complete* form of knee-joint dislocation backward, displacement is not so great as in dislocation forward. The head of the tibia projects posteriorly and above, the femoral condyles anteriorly and below; the leg is, as a rule, partly flexed, but it may be extended, and there is moderate shortening. In *incomplete* dislocation the symptoms are less marked.

Treatment.—The treatment of backward dislocation of the knee-joint is the same as for forward dislocation.

Dislocation Outward of the Knee-joint.—Is usually incomplete. The inner tuberosity of the tibia in outward dislocation lies upon the outer condyle of the femur (Pick); the inner condyle of the femur projects internally; the outer tibial tuberosity and fibular head project externally, the former having a depression below it, and the latter above it; the leg is semiflexed, but shortening is absent.

Dislocation Inward of the Knee-joint.—Is usually incomplete. The outer tuberosity of the tibia in inward dislocation lies upon the inner condyle of the femur; the outer condyle of the femur forms an external prominence, and the inner tuberosity of the tibia forms an internal prominence. Pick cautions us not to mistake a separation of the lower femoral epiphysis for lateral dislocation (the former is reduced easily, the deformity tends to recur, and there is soft crepitus).

Fig. 317.—Old dislocation of the patella outward.

Treatment.—In treating lateral dislocation of the knee-joint, effect extension and counter-extension as in anteroposterior dislocations. The leg is moved from side to side and attempts are made at rotation. The after-treatment is the same as that for anteroposterior luxations.

Dislocations of the Patella.—Are usually acquired. There are thirty-five congenital cases on record (Bajardi). There are three forms: outward,

inward, and edgewise. The so-called dislocation upward is in reality rupture of the ligamentum patellæ (page 642).

Dislocation outward (Fig. 317) may be due to muscular action or to direct force, and occurs during extension of the leg. It occasionally happens in a person with knock-knee. If dislocation is complete, the bone lies upon the external surface of the external condyle; if incomplete, the patella rests upon the anterior surface of the external condyle. The leg is extended, flexion is impossible, and attempts at flexion produce great agony. In the patient shown in Fig. 317, flexion became possible in an unreduced dislocation, but not until months after the accident. The knee is wider than normal. There is a hollow in front of the joint. The bone is felt in its new position.

Dislocation inward is very rare. The signs are like those of dislocation outward, except that the patella rests upon the inner condyle.

Treatment.—Give ether. Raise the body upon a bed-rest, and flex the thigh. Grasp the patella, depress the margin of the patella which is farthest from the center of the joint (Pick). The muscles pull the bone into place. Immobilize for three weeks, and then begin passive motion. Incision may be necessary in order to effect reduction.

Dislocation of the Patella Edgewise.—The patella rotates vertically, one edge resting between the condyles. As a rule, the outer border is in the intercondyloid notch (Pick). This condition is produced by direct force when the extremity is partly flexed. Twisting and muscular action have been assigned as causes. The condition is obvious at a glance.

Treatment.—Give ether. Pick recommends "sudden and forcible bending of the knee." In some cases the bone can be pushed into place, the limb being extended and flexed as in the reduction of a lateral dislocation. In some cases incision will be necessary.

Dislocation of the Semilunar Cartilages of the Knee-joint (*the Internal Derangement of Hey; Subluxation of the Knee-joint*). The condition was described by Hey of Leeds in 1803. The interarticular cartilages of the knee-joint are attached in front of and behind the tibial spine, and the convexity of each cartilage is attached to the edge of the corresponding tibial tuberosity by means of the coronary ligament. The internal cartilage is fastened to the internal lateral ligament and has a moderate freedom of movement. The outer cartilage is not connected with the internal lateral ligament and is not freely movable. It has been stated that the outer cartilage is more frequently dislocated than the inner, but modern experience indicates that this is not true, and that the internal cartilage is the one most apt to suffer. In 17 cases operated upon by Barker, the internal cartilage was involved in every case ("Lancet," Jan. 4, 1902). Those persons whose occupations force them to pass considerable time upon their knees are predisposed to this accident (Annandale). The derangement of the cartilage is usually caused by a sudden external rotation of the tibia, while the knee-joint is in partial flexion; for instance, when the patient stumbles over an obstacle, the knee-joint being partially flexed, the tibia is twisted outward. When the joint is flexed, a normal cartilage moves backward, and when it is extended, moves forward again. When the cartilage is thrown out by the sudden eversion and flexion of the tibia, it is caught and does not move into place readily when the leg is extended. The tear takes place in the direction of the fibers of the cartilage.

Symptoms.—The indications of interarticular cartilage displacement are a sudden, violent, sickening pain in the knee, which may be so severe as to cause the patient to fall to the ground. The knee is in a position of fixed semiflexion. Further flexion is possible, but extension is impossible. In some cases the patient can voluntarily make further flexion; in others, the pain is so severe that he either cannot or will not do it; but increase of flexion can be obtained by passive motion. The joint is, however, blocked both to passive and to voluntary extension. Attempts at passive motion are productive of fierce pain. If either cartilage is displaced away from the tibial spine, a prominence may be found on one or the other side of the knee-joint. If the displacement takes place toward the tibial spine, a prominence may be found on one side of the ligament of the patella. Subluxation is rapidly followed by inflammation of the synovial membrane of the joint and of the cartilages themselves; and swelling quickly masks the projection of the cartilage. This accident is frequently mistaken for the blocking of the joint by a floating cartilage; but a dislocated cartilage always remains in the same position, and a loose cartilage changes its position from time to time (Turner). Loose bodies in a joint produce pain of a shifting character, and interference with both flexion and extension, or with either flexion or extension in an irregular way (Cotterill). In regard to the diagnosis, Cotterill points out that in a sprain of the joint extension is not painful, but flexion is interfered with; whereas, in the dislocation of a cartilage of the joint, flexion is still possible, but extension cannot be carried out ("Lancet," Feb. 22, 1902).

Treatment.—In treating dislocation of a semilunar cartilage of the knee give ether and reduce by forced flexion and external rotation. Extension becomes possible if the cartilage is freed. During these maneuvers an assistant endeavors to push any projection of cartilage into place. After reduction apply a splint for two weeks and combat inflammation by proper remedies (see Synovitis); then begin passive motion. At the end of two weeks apply a firm knee-cap made of leather and let the patient get about on crutches. After a couple of weeks the crutches can be laid aside. As recurrence of the displacement is usual, the patient should wear a knee-cap during the day for many months. A partial tear may entirely heal when thus treated by rest and support; an extensive tear will not, although even in such cases a useful but somewhat stiff joint may be obtained. If it is found impossible to unlock the blocked joint, or if the tear is extensive and redislocation is prone to occur, an operation is advisable. The joint is opened and the loose cartilage is pushed into place and held by stitches or the loosened portion is excised.

Dislocations of the Fibula: Dislocation at the Superior Tibiofibular Articulation.—This injury is rare. The head of the fibula may go forward or backward. The *causes* are direct force and violent adduction of the foot with abduction of the knee (Bryant).

Symptoms.—After dislocation of the fibula the position is one of semiflexion of the knee, voluntary extension and flexion being impaired or lost. A distinct movable projection is readily noticed in front or behind, which is found to be continuous with the fibula. There is a depression over the normal position of the head of the fibula.

Treatment.—In treating dislocation of the fibula bend the knee to relax

the biceps, and proceed to push the bone into place. Put a compress over the head of the fibula, apply a bandage, and put the limb on a double inclined plane for three weeks. At the end of this time put a lacing knee-support upon the knee and let the patient up. Displacement being liable to recur, a knee-cap must be worn for a year.

Dislocations of the Ankle-joint.—These injuries are not unusual. Fracture is a frequent complication. There are five forms of ankle-joint dislocation—outward, inward, forward, backward, and upward.

Lateral dislocations of the ankle-joint are either outward or inward, and may be complete or incomplete. In these dislocations the astragalus rotates. In incomplete dislocations "there is no great separation of the trochlear surface of the astragalus from the under surface of the tibia, but the outer or inner margin of this surface is brought into contact with the articular surface of the tibia, and the whole foot presents a lateral twist" (Pick). The *causes* of these dislocations are twists of the joint.

Symptoms.—Incomplete outward dislocation of the ankle-joint is known as *Pott's fracture* (see page 541). Complete outward dislocation, in which the articular surface of the astragalus is completely displaced outward from the articular surface of the tibia, and which condition is associated with a fracture of the fibula and separation of the inferior tibiofibular articulation, is known as *Dupuytren's fracture.* In incomplete dislocation the foot goes outward and upward, the fibula is fractured, and the tibiofibular ligaments are torn off. In Dupuytren's fracture the ankle is broad, the inner malleolus projects and looks lower than natural, the outer malleolus ascends with the foot, the foot rotates outward, and crepitus can be detected. In inward dislocation which is associated with fracture of the inner malleolus there is inversion, the outer malleolus projects, and crepitus can be detected. In incomplete separation the symptoms are similar, but are not so marked.

Treatment.—In treating a case of dislocation of the ankle-joint the deformity is reduced by flexing the leg on the thigh and the thigh on the pelvis; an assistant makes counter-extension from the knee; the surgeon makes extension from the foot, and at the same time rocks the astragalus into place. Dupuytren's fracture is treated in the same manner as Pott's fracture (page 542). Dislocation inward is treated in a fracture-box for the same period as Pott's fracture.

Anteroposterior dislocations of the ankle-joint are rare. The *cause* is the catching of the foot in jumping or falling—direct violence. In dislocation forward the foot is lengthened, the heel is not conspicuous, the tibia and fibula project against the tendo Achillis, and the relation of the malleoli to the tarsus is altered. In incomplete dislocation the symptoms are similar, but less pronounced. In dislocation backward the foot is shortened, the tibia and fibula project in front, the heel is prominent, and the relation between the malleoli and the tarsus is altered. In incomplete dislocation the symptoms are similar, but less marked.

Treatment.—In anteroposterior dislocation of the ankle-joint, reduce as in lateral dislocations. Sometimes the tendo Achillis must be cut. Apply a plaster-of-Paris dressing, and let it be worn for two weeks; then begin passive motion, and let the patient wear side-splints for a week longer.

Dislocation upward of the ankle-joint, or Nélaton's dislocation, is

a very rare injury. The astragalus is wedged between the widely separated tibia and fibula. This dislocation is usually associated with fracture. The *cause* is a fall upon the feet from a great height.

Symptoms.—Upward dislocation of the ankle-joint is indicated by the widening of the ankle and by the flattening of the foot. The malleoli are nearly on a level with the plantar surface of the foot, and there is absolute rigidity.

Treatment.—In treating upward dislocation of the ankle-joint give ether, and try to reduce by powerful extension and counter-extension. Treat the injury afterward in the same manner as an anteroposterior luxation.

Dislocation of the Astragalus.—The astragalus may be displaced from the bones of the leg and at the same time be separated from the rest of the tarsus. The displacement may be forward, backward, outward, inward, or rotary.

Dislocation of the astragalus forward or backward is caused by falls or twists.

Symptoms.—In forward dislocation the astragalus projects strongly; there is shortening of the foot, and the malleoli approach the plantar aspect of the foot; the foot is deviated to one side or to the other, and there is absolute rigidity of the ankle-joint. In incomplete luxations the symptoms are similar, but less marked. This dislocation may be obliquely forward. In backward dislocation of the astragalus the foot is not deviated to either side; the astragalus projects between the malleoli and above the os calcis, and the tendo Achillis is stretched over the projection. Rigidity is absolute. This dislocation may be obliquely backward.

Lateral and Rotary Dislocations of the Astragalus.—Lateral dislocations of the astragalus are rare, are always compound, and are always associated with fracture. In rotary dislocation the astragalus remains in its normal habitat after rotating on its own axis, either horizontal or vertical. The *causes* of rotary dislocation are twists of the foot when it is at a right angle to the leg (Barwell). The *symptoms* of rotary dislocations are obscure. There is rigidity, but sometimes portions of the astragalus may be made out.

Treatment of Dislocations of the Astragalus.—In treating astragalus dislocation reduce under ether by flexing the knee to relax the gastrocnemius, extending the foot, and pushing the bone into place. It may be necessary to cut the tendo Achillis. After reduction put up the foot and leg in a plaster-of-Paris dressing for two weeks, and then begin passive motion and apply side-splints, which are to be worn for one week more. If reduction fails, support the limb on splints, combat inflammation, and endeavor to bring about union between the dislocated bone and the tissues. Often, in unreduced dislocation, the skin sloughs over the projecting bone. Excision is demanded the moment sloughing is seen to be inevitable. Cases of compound dislocation of the astragalus require immediate excision.

Subastragaloid Dislocation.—This condition is a separation of the astragalus from the os calcis and scaphoid, without separation from the bones of the leg. Pick states that the usual classification for these dislocations is forward, backward, inward, and outward, but that the displacement is, as a rule, oblique, the foot passing backward and outward or backward and inward. The *cause* is twisting.

Symptoms.—In subastragaloid dislocation the astragalus projects on the dorsum; the foot is everted in outward dislocation and inverted in inward dislocation; the relation of the malleoli to the astragalus is unaltered; the ankle-joint is not absolutely rigid; the foot "is shortened in front and is elongated behind" (Pick).

Treatment.—To treat subastragaloid dislocation make extension in the direction opposite to that of the displacement. In dislocation of the tarsus backward fix a bandage around the foot, on a level with the heads of the metatarsal bones, which bandage the surgeon ties around his shoulders. The surgeon puts one knee in front of the ankle and thus fixes the leg, raises himself up to make extension upon the tarsus, and moulds the bone into position. Tenotomy may be necessary. After reduction apply a plaster-of-Paris dressing and have it worn for three weeks. The ankle-joint, fortunately, is not involved, and stiffness of this articulation need not be apprehended. If reduction is impossible, take the same course as in luxations of the astragalus.

Dislocations of the other tarsal bones are very rare. Single bones may be dislocated, or the luxation may occur at the mediotarsal articulation.

Symptoms and Treatment.—Projection is an obvious symptom in dislocation of the other tarsal bones. The *treatment* is to reduce by extension and moulding, the part being put up in plaster-of-Paris dressing for two weeks.

Dislocations of the metatarsal bones are rare.

Symptoms and Treatment.—Shortening of the toes and projection of the dislocated bone are symptoms of dislocation of the metatarsal bones. To *treat* these dislocations reduce by extension under ether and put up in a plaster-of-Paris dressing for two weeks. If reduction fails, the functions of the foot will not be much impaired.

Dislocations of the phalanges are very rare. The first phalanx of the big toe is the one most liable to dislocation.

Symptoms and Treatment.—Dislocations of the phalanges are obvious. The treatment is by reduction as in dislocations of the thumb. Immobilize for two weeks.

Operations upon Bones and Joints.

Osteotomy.—By the term *osteotomy* the modern surgeon means literally the sectioning of a bone for the purpose of straightening a limb ankylosed

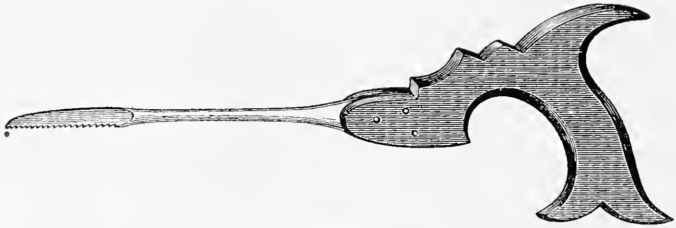


Fig. 318.—Adams's large saw.

in a bad position, correcting a bony deformity, or amending a vicious union of a fracture. In a *linear osteotomy* the bone is transversely or obliquely divided at one spot; in a *cuneiform osteotomy* a wedge-shaped portion of

bone is removed. The operation of osteotomy may be performed with a saw (Fig. 318) or with an osteotome. The saw creates dust, draws much air into the wound, and lacerates the tissues to a considerable degree. Most surgeons prefer the chisel or the osteotome. The osteotome slopes down to a point from each side (Fig. 319); the chisel is straight on one side and on the other is bevelled to a point.

Fig. 319.—Osteotome.

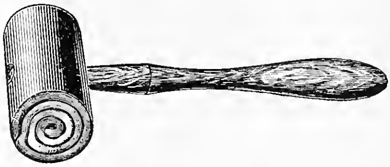


Fig. 320.—Rawhide mallet.

Osteotomy for Genu Valgum, or Knock-knee (Macewen's Operation, Fig. 321).—In this operation the instruments required are the scalpel, hemostatic forceps, osteotomes of several sizes, a mallet (Fig. 320), and a sand-bag wrapped in an aseptic towel.

Operation.—The patient lies upon his back, being rolled a little toward the diseased side. The leg of the diseased side is partly flexed upon the thigh and the thigh upon the pelvis, and the extremity is laid upon its outer surface, the sand-bag being pushed between the extremity and the bed, opposite to the site of section. The flexion of the knee relaxes the popliteal

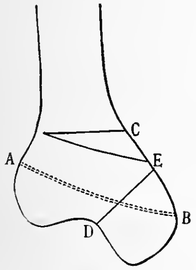


Fig. 321.—Osteotomy of the right femur in a case of knock-knee: A B, Epiphyseal line; C, section of Macewen; D E, section of Ogston.

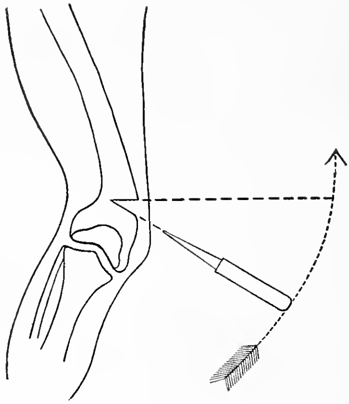


Fig. 322.—Macewen's operation for genu valgum. The chisel is held in the line for striking with a mallet; the arrow shows the direction in which the chisel is levered up and down so as to make a wide gap in the bone (after Barker).

vessels and saves them from injury. The surgeon, if operating on the right leg, stands outside of that extremity; if operating on the left leg, he stands opposite the left hip (Barker). The knife is inserted into the tissues and carried to the bone at the inner side of the knee, just in front of the adductor tubercle of the inner condyle and on a level with the upper border of "the patellar articular surface of the femur" (Barker). An incision is made upward one inch in length, in the direction of the axis of the femur. At the lower angle of this wound an osteotome is inserted and the blade after

insertion is turned to a right angle with the shaft of the femur, half an inch above the epiphysis (Fig. 321). The osteotome is struck several times with a mallet; the handle is moved several times toward and from the body, so as to widen the cut in the bone (Fig. 322); the osteotome is again struck with the mallet several times; it is again moved toward and from the body, and this process is continued until the bone is cut two-thirds through. If the osteotome becomes tightly fixed, it should be withdrawn and a smaller one introduced. In the soft bone of a young child this to-and-fro movement of the chisel, if carefully executed, is not liable to break the instrument. In dense bone it may break the instrument; hence, when doing an osteotomy in dense bone, the osteotome is moved to and fro across the limb and slight downward pressure upon the handle will to a great extent prevent binding. When the bone is cut two-thirds through, the osteotome is withdrawn, a piece of wet antiseptic gauze is held over the wound, and the surgeon fractures the femur by strong adduction. The wound is neither sutured nor drained, but is dressed antiseptically, the entire extremity is wrapped in cotton, and a plaster-of-Paris dressing is applied and carried up to the groin. The dressing may be removed in two weeks, and the patient may subsequently be treated with sand-bags, as for an ordinary fracture of the thigh, but without extension. This operation is scarcely ever fatal.

Ogston's Operation (Fig. 321).—In this operation the internal condyle is sawed off obliquely with an Adams saw—a proceeding which permits the straightening of the knee. The objection to the procedure is that it opens the knee-joint, and that this cavity fills up more or less with a mixture of blood and bone-dust. Macewen's operation is decidedly the safer.

Osteotomy for a Bent Tibia.—In this operation the instruments required are the same as those used in the above operation. The tibia is divided transversely or obliquely (linear osteotomy), or a wedge-shaped piece is removed (cuneiform osteotomy). The oblique incision is the best. If the convexity of the tibial curve is inward, cut the bone from above downward and from in front backward; if the curve is forward, section the bone from above downward and from within outward. The fibula need rarely be interfered with. After the osteotomy the limb is treated just as it would be for a fracture.

Osteotomy for Faulty Ankylosis of the Hip-joint.—This operation is performed in order to allow straightening of a limb that has undergone bony ankylosis in a faulty or an inconvenient position. In some cases an attempt is made to obtain a movable joint, but in most cases the surgeon must be satisfied with an ankylosis in extension. Osteotomy may be performed through the neck of the femur or through the shaft of the femur below the trochanters.

Osteotomy through the neck of the femur is performed (1) with a saw (Adams's operation) or (2) with an osteotome.

1. *Adams's Operation* (Fig. 323).—In this operation the instruments required are a scalpel, hemostatic forceps, a long, blunt-pointed tenotome, and an Adams saw.

Operation.—The patient lies upon his sound hip; the surgeon stands upon the side to be operated upon, and back of the patient. The knife is entered a finger's breadth above the great trochanter, is pushed in until it strikes

the neck of the bone, is then carried across the front of and at a right angle with the neck, and is withdrawn, enlarging the wound, in the soft parts as it emerges, to the extent of an inch. The saw is then introduced and the neck of the femur is entirely divided. After the osteotomy dress the wound antiseptically and place the extremity straight. To straighten the limb it may be found necessary to cut contracted tendons and fascial bands. After securing extension and applying dressings use the weight-extension apparatus and the sand-bags. Begin passive movements from the start if a movable joint is desired; few patients can tolerate the pain necessary to bring this about. If it is determined to aim for a stiff joint, treat the case as an intracapsular fracture would be treated.

2. *With an Osteotome.*—The instruments required in this operation are the same as those used for genu valgum. A sand-bag is not needed. The position of the patient is the same as that in Adams's operation. An incision one inch long is made, starting just above the great trochanter, ascending in the axis of the femoral neck, and reaching to the bone. An osteotome is introduced, is turned to a right angle with the neck of the bone, and is struck with a mallet until the bone is *completely* divided. (It is not to be divided partially and then broken.) The after-treatment is the same as that for Adams's operation. The operation with the osteotome is to be preferred to that by the saw.

Osteotomy of the Shaft of the Femur below the Trochanters (Gant's Operation).—In this operation (Fig. 323) the saw may be used, but the osteotome is to be preferred. The instruments employed are the same as those used for Adams's operation, plus an osteotome.

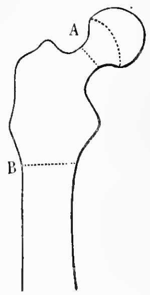


Fig. 323.—Osteotomy through the neck of the femur: A, Adams's operation; B, Gant's operation.

Operation.—The position in Gant's is like that in Adams's operation. A longitudinal incision one inch long is made upon the outer aspect of the femur and on a level with the lesser trochanter. The osteotome is inserted and the bone is completely divided below the lesser trochanter. The after-treatment is the same as that for Adams's operation. Gant's operation is the best method for correcting faulty position in bony ankylosis, and Adams's operation can only be employed in those cases where the femur still has a neck which is practically unchanged.

Osteotomy for Faulty Ankylosis of the Knee-joint.—This operation is performed for bony ankylosis of a knee in a position of flexion. The instruments employed are the same as those used for genu valgum.

Operation.—The patient lies upon his back with his thighs flat upon the bed, the legs hanging over the end of the bed. The surgeon stands on the patient's right side. Just above the patellar articular surface upon the femur a transverse incision is made, one inch in length and reaching to the bone. The osteotome is introduced and the bone is cut *nearly* through. The leg is then forcibly extended. It must not be extended too violently, or the popliteal vessels may be injured. In cases where the structures of the popliteal space are tense, the leg must not be brought at once into extension, but this position should be attained gradually by means of weights. The

wound is dressed aseptically, and the extremity is placed upon a double inclined plane and is treated as for fracture near the knee-joint.

Osteotomy for vicious union of a fracture is performed in case of angular deformity, and is carried out in the same manner as are the above procedures. It is best, when possible, to enter the osteotome upon the concavity of the bent bone, so that the periosteum will not rupture when extension is made, and the patient will in consequence gain a longer limb.

Osteotomy for Hallux Valgus.—In this operation a linear osteotomy is made through the neck of the metatarsal bone of the great toe, the toe is forcibly adducted, and a splint is applied to the inside of the foot and the toe.

Osteotomy for Talipes Equinovarus.—The instruments required in this operation are a scalpel, hemostatic forceps, a narrow, blunt-pointed saw, special directors, bone-cutting forceps, sequestrum forceps, and scissors.

Operation (after Barker).—The patient lies upon his back, the thigh is semiflexed, the knee is bent, and the sole of the foot rests upon the table. The surgeon stands to the right side if it is the right limb which is to be operated upon, or to the left side if it is the left limb. The surgeon feels for the outer surface of the cuboid bone, and cuts away from over the latter a piece of skin corresponding in size with the bone-wedge intended to be removed (this piece of skin must include the bursa which forms in these cases). The foot is then turned outward, the astragaloscaphoid articulation is located, and over this an incision is made "from the lower to the upper dorsal border of the scaphoid bone" (Barker), reaching through the skin only; the foot is placed again in the first position, all the soft parts are raised from off the superior surface of the tarsus, and a triangular surface corresponding with the base of the wedge to be removed is cleared; a "kite-shaped" director (Fig. 324) is passed into the external wound and projected from the internal wound; the saw is pushed through the groove of the director nearest the toes, and is made to cut through the tarsus, from the dorsum to the sole, at right angles to the metatarsal bones; the saw is pushed through the groove of the director nearest the ankle, and is made to cut from the dorsum to the sole, at right angles to the long axis of the calcaneum; the wedge-shaped piece of bone is grasped with sequestrum forceps and cut out with scissors, with bone forceps, or with a blunt bistoury. The wound is well irrigated, the foot is straightened, the internal wound is sewed up, the external wound is sutured except at its lowest portion, where a drainage-tube is to be retained for twenty-four hours, and the wound is dressed antiseptically. The foot is put up in plaster or upon a Davy splint.

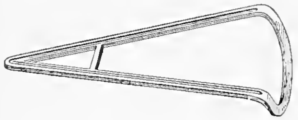


Fig. 324.—Davy's director (Pye).

Osteotomy for Talipes Equinus.—This operation is described by Mr. Davy, who devised it, as follows:* "Taking the line of the transverse tarsal joint as a guide, on the outer and inner sides of the foot, and immediately over the joint, two wedge-shaped pieces of skin are removed, equal in extent to the amount of bone demanded. The soft structures are freed on the dorsum of the foot in the way previously described; but, as the base of the

* Barker's "Manual of Surgical Operations."

osseous wedge for equinus cases is at the dorsum and its apex at the sole, the parallel wire director, instead of the kite-shaped varus one, is used. The saw is successively inserted in its grooves, and by keeping in mind the idea of a keystone a clean wedge of bone is cut out from the dorsum to the sole of the foot." The wedge is extracted, and the foot is straightened and is put up in plaster-of-Paris or is placed on a Davy splint.

Operative Treatment of Recent Fractures.—In recent fractures where reduction is impossible or where displacement recurs in spite of splints, it may be advisable to operate. In doubtful cases a skiagraph should always

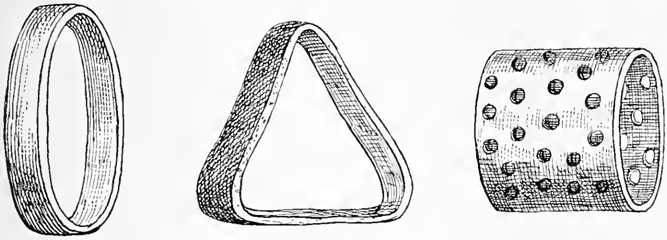


Fig. 325.—Bone ferrules (Senn).

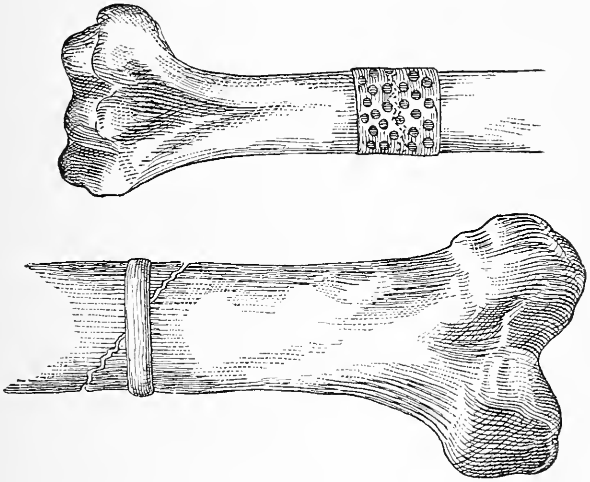


Fig. 326.—Bone ring and ferrule applied (Senn).

be taken, and it will often decide whether operation is or is not indicated. In most instances of irreducible fracture reduction of the fragments is impossible because muscle or fascia is caught between them or because the periosteal soft parts have hardened and shortened as a result of hemorrhage and inflammation. In such cases it may be necessary to make a tolerably long incision; loosen the ends of the fragments from their anchorage, cut the inflammatory ties, remove tissue from between the fragments, and, if the ends are very irregular, saw them off evenly.

The fragments are bored and brought together, and are held by silver wire or kangaroo-tendon, or both fragments are surrounded by Senn's bone ferrule or bone ring, and fixation is thus secured (Figs. 325, 326). Drainage

is unnecessary, the soft parts are sutured and dressed with sterile gauze, and the extremity is put up in plaster-of-Paris. If the clavicle is operated upon, after sterile dressings are applied a Velpeau bandage is put on, and the turns of this bandage are overlaid with plaster-of-Paris, a trap-door being cut over the seat of operation. In an operation for recent fracture the author does not use an Esmarch bandage, as he believes it best to see what is cut and thoroughly arrest bleeding at the time, rather than run the danger of oozing and infection.

The author has wired recent fractures of the humerus, tibia, femur, and clavicle. Arbuthnot Lane believes that every very oblique fracture of the tibia and fibula low down should be treated by incision and fixation.* It is necessary to bear in mind that if one of two parallel bones is broken (as the radius alone or tibia alone), and it is found necessary to resect a considerable portion, a like amount should be resected from the companion bone in order to prevent great deformity.

Recent Transverse Fracture of the Patella.—(See page 534.)

Bone-grafting, or Transplantation.—(See page 438.)

Operative Treatment of Ununited Fracture.—The instruments required in this operation are a scalpel, hemostatic forceps, dissecting forceps,

Fig. 327.—Hamilton's improved bone-drills.

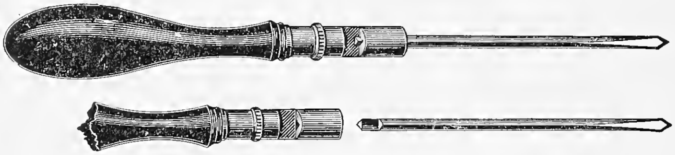


Fig. 328.—Brainard's drills with Wyeth's adjustable handles.

retractors, Allis's dissector, an awl or special drill (Figs. 327, 328), chisels, a mallet, a fine saw, lion-jaw forceps, and silver wire.

In operating, incise longitudinally down to the seat of fracture, retract the periosteum from the bone, drill the bones before cutting them, chisel away the material of imperfect union, saw through each bone end far enough from the seat of fracture to reach sound tissue, pass large silver wires through the holes (this wire should be one-tenth inch in diameter for the femur, one-sixteenth inch for the patella, etc.) (Fig. 331), twist the wires a fixed number of times (two complete turns) in the direction that the hands of a watch move (this is Keen's direction. In case removal of the wires should be demanded later we know how to untwist them), sever the ends of the wires, and hammer their stems against the bones. The wires may never require removal. Dress the part as a recent fracture. Various plans besides wiring have been employed in ununited fracture. Gussenbauer's

* Brit. Med. Jour., April 20, 1895.

clamp is used by some. Clayton Parkhill's bone-clamp is a very useful appliance, and holds the fragments firmly in contact (Fig. 215). Menard and Lannelongue inject a 1 : 10 solution of chlorid of zinc between the fragments and around their ends, and then immobilize the parts. Some surgeons unite the fragments with kangaroo-tendon instead of wire (suturing of bone); others use nails of bone or ivory; others use screws. Senn asserts that the above methods will not hold fragments in contact if these fragments have a tendency to become displaced. Senn fastens the bones together by hollow cylinders of decalcified bone or ivory, the cylinders being perforated in many places (bone ferrules) (Figs. 325, 326). The soft parts are sutured, no drain is used, and the limb is encased in plaster-of-Paris.

Ununited Fractures of the Femoral Neck.—Loreta did the first successful operation for this condition about seventeen or eighteen years ago. The operation is not adapted to the aged, but should certainly be employed in youths and middle-aged individuals if the general condition of the patient or

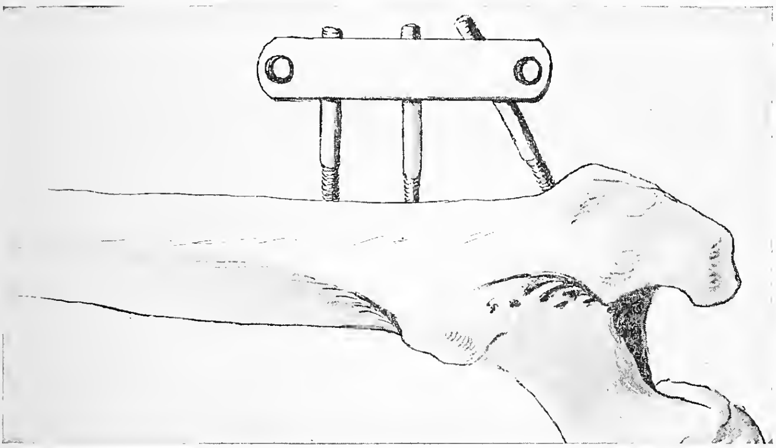


Fig. 329.—Method of securing screw of Freeman's apparatus in fracture of neck of femur; the wooden plates embracing screws (Freeman, in "Annals of Surgery," Oct., 1904).

some particular diseased state does not forbid, and if pain is severe and disability is pronounced.

Leonard Freeman advises an anterior incision beginning below and external to the anterior superior iliac spine and extending downward, external to the sartorius, for 3 or 4 inches ("Annals of Surg.," Oct., 1904). When the fragments are exposed, the connective tissue between them is cut away by means of scissors, the surfaces of the fragments are freshened with a chisel or a curet, oozing is arrested by pressure and hot water, and loose osseous splinters are removed (Freeman). Some surgeons have fixed the fragments together by nails, screws, or pegs of bone or ivory, access to the trochanter being best obtained for this purpose by making a second incision over the outer portion of that bony process. As Freeman points out, however, the head is often so very soft that none of these appliances will obtain fixation.

Freeman has devised a clamp for this purpose (Figs. 329, 330). An additional incision is made over the trochanter and holes are bored for the clamp

screws, one hole being drilled "through the base of the trochanter, the external fragment of the neck, and into the head of the bone" ("Annals of Surgery," Oct., 1904). The wound is closed, dressings are applied, and extension is made on a long side splint, a pad being placed beneath the trochanter to prevent the disposition to pass backward, which movement, if it occurs, will cause external rotation of the limb and separation of the fragments. In about eight weeks the extension is removed and the patient is gotten about on crutches.

In Freeman's case the screws were removed in two weeks because of infection of the cancellous tissue. A similar condition arose in Davis's case in which two steel drills were used.

According to Freeman, 14 operations for ununited fracture of the femoral neck are on record ("Annals of Surgery," Oct., 1904). Four of these cases were done by G. G. Davis. Cobb finds six additional cases and reports one of his own (Farrar Cobb in "Boston Med. and Surg. Jour.," May 10, 1906).

Ununited Fracture of Patella.—An incision is made in the long axis of

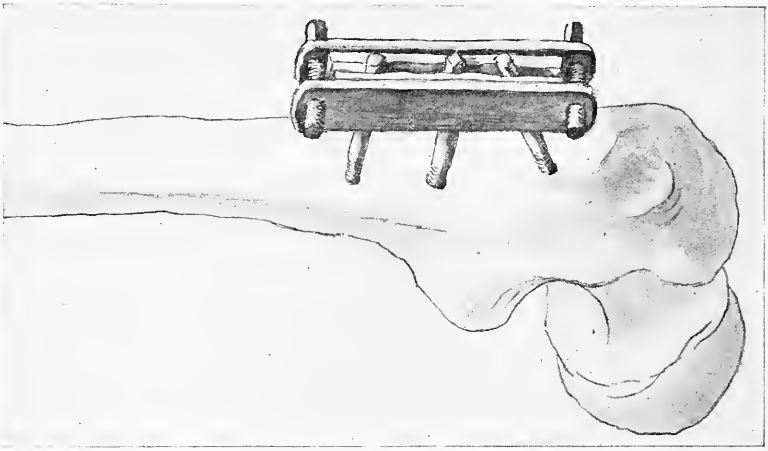


Fig. 330.—Completed screw and clamp of Freeman's apparatus for fixation of fracture of neck of femur (Freeman, in "Annals of Surgery," Oct., 1904).

the limb, over the middle of the space between the fragments, from well above the upper fragments to well below the lower piece; this incision divides all the soft parts. The soft parts are retracted, but the periosteum is undisturbed; each fragment is bored (Fig. 332, 1) in one or two places; the surfaces of the fragments are cut square through sound bone with a saw; all old reparative material is cut away; the wires are passed through the perforations, twisted, cut off, and hammered down (Fig. 332, 2). If the bone fragments cannot be approximated, it may become necessary to incise the muscle around and above the patella or partially to separate the tuberosity of the tibia and bend this process upward. A small drain is inserted above the bone, the wound is sutured, aseptic dressings are applied, and the limb is put upon a Macewen splint.

Treves's Operation for Caries of the Lumbar and Last Dorsal Vertebræ.—The instruments required are a scalpel, hemostatic forceps, grooved director, an Allis dissector, sequestrum forceps, curet spoons, and a sand-bag. We will describe the operation as performed on the right loin.

Operation.—The patient lies upon his left side, with the knees drawn up and a sand-bag under the left loin. The surgeon stands behind the patient (Barker). An incision is made at the outer border of the erector spinæ mass, reaching from the last rib to the iliac crest and going down at once to the lumbar fascia. The lumbar aponeurosis is opened, the erector spinæ muscle is retracted inward, and the anterior portion of the erector spinæ sheath is incised. The quadratus lumborum muscle is next cut, and then the anterior leaflet of the lumbar aponeurosis is slit. The abscess is thus reached and opened and tuberculous pus flows out. The cavity is carefully irrigated. The abscess cavity is irrigated with quantities of warm corrosive sublimate solution (1:5000). The cavity is filled, the fluid is allowed to flow out, its exit being aided by pressure in front and changes of posture; the cavity is filled again, and so on, and, after all loose débris is removed, the bodies of the vertebræ are carefully examined with the finger and diverticula are opened. Loose pieces of bone are removed with spoons or forceps, and cavities are thoroughly but lightly cureted, as in some places the wall is very thin. By means of properly shaped spoons carious bone can be removed even from the anterior surface of the column (Treves). Thus the wall of the abscess is completely removed. Finally all débris is washed out by irrigation with mercurial solution; any mercurial solution which might remain is washed out with warm water or salt solution, and the interior of the cavity is wiped dry. At this stage most operators introduce iodoform emulsion. Whether or not this is done, "the wound is closed by a series of silkworm-gut sutures, passed sufficiently deep to include the greater part of the muscular and tendinous structures with the skin" (Treves's "Operative Surgery").

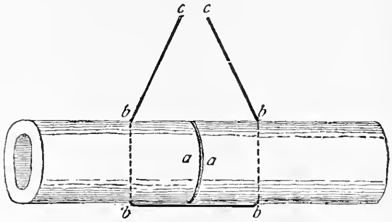


Fig. 331.—Wiring of bones for ununited fracture: *a a*, Sawn surfaces approximated after removal of old material which was interposed between the fragments; *b b*, *b b*, perforations drilled completely across the bone; *c*, *c*, wires ready for twisting.

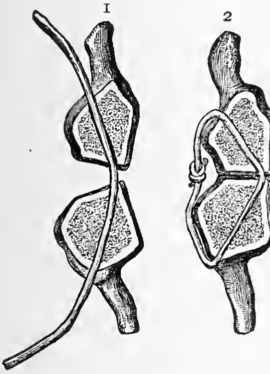


Fig. 332.—Wiring of the patella: 1, Fragments cut and cleaned and the wires passed; 2, wires twisted and hammered down upon the bone (after Barker).

Aspiration of Joints.—In certain cases of joint-effusion from inflammation, tuberculous or otherwise, and sometimes in hemorrhage into a joint, it is desirable to remove the fluid by aspiration. The pneumatic aspirator is used (Fig. 333). The trocar and cannula are thoroughly asepticized and the joint is prepared as for a set operation. The needle is entered at a surface free from vessels. The directions for using an aspirator are as follows: insert the stopper firmly into a strong bottle (preferably a clear glass one), then attach the short elastic hose to the stopcock *B* of the tube projecting

from the stopper, and attach the other end of the same elastic hose to the exhausting or inward-flowing chamber of the pump. Next attach one end of the longer elastic hose to the stopcock *A* projecting from the stopper and the other end to the needle. Care should be taken that all the fittings or attachments are placed firmly into their respective places. Now close the stopcock *A* and open the stopcock *B*. By giving from thirty-five to fifty strokes of the pump a sufficient vacuum can be produced to fill with the fluid from the joint a bottle holding from a pint to a quart. After having formed the vacuum, close the stopcock *B*, and insert the needle in the joint. When the stopcock *A* is opened, suction through the needle draws the fluid from the joint. The trocar may also be used to inject antiseptic agents. After the completion of aspiration the part is dressed antiseptically and the extremity is put at rest upon a splint.

Excisions of Bones and Joints.—The ancients practised excision and resection for compound dislocations and fractures. The operation was first formally advised as a substitute for amputation in joint disease by Mr.

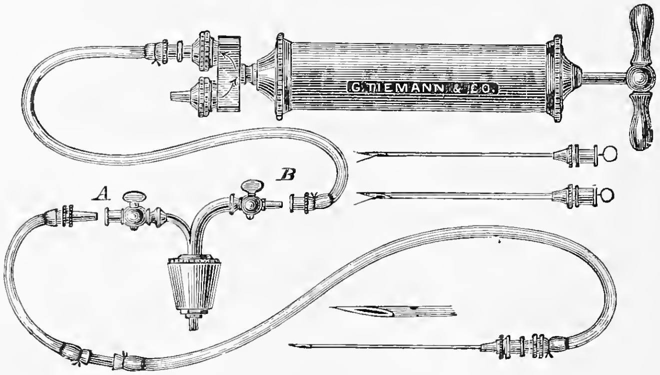


Fig. 333.—Aspirator and injector.

Park in 1782. The terms excision and resection are usually employed as synonymous, but such a use is not strictly accurate. According to Professor Ashhurst, the term excision means "the removal of an offending part without that total ablation of the affected portion of the body which is implied by the term amputation. Hence we speak of excisions of tumors, of joints, of the eyeball, etc." *Resection* has a more restricted meaning; it signifies "an operation which takes away a middle portion and brings the ends together again, and is thus in strict surgical language limited to partial excisions of the long bones" (International Encyclop. of Surgery, edited by John Ashhurst, Jr.). Excision of a joint is the removal of the articular portions of the bones of the joint, and also the cartilage and synovial membrane. In the hip-joint and shoulder-joint only the head of the long bone may be removed, and not the articular surfaces of both bones. In partial excision of a long bone excision (resection) for bone disease enough bone is known to have been removed only when the remaining bone bleeds. *Complete excision* of a bone is the removal of an entire bone. *Partial excision* or *resection* is the

removal of a portion only of a bone. Excision is a conservative operation which often averts amputation.

Excision may be performed by the *open* method, in which the periosteum is not preserved, or it may be performed by the *subperiosteal* method, in which the periosteum is carefully separated by a rugine and the capsular ligament is preserved. *Arthrectomy*, or *erasion*, is the excision of the diseased synovial membrane and ligament, and also small foci of disease of bone and cartilage.

Excision may be employed for compound dislocation, and in compound dislocations of the elbow and the shoulder it is usually performed. Excisions for compound dislocations in other large joints are very dangerous; they are rarely attempted in battle-field practice, and are to be avoided even in civil practice unless the patient is young and vigorous and every advantage can be given him during the operation and convalescence. Excision for deformity is rarely performed except upon the hip, the knee, and the shoulder, and these excisions must not be employed if the patient's condition leads one to fear the result of a protracted convalescence. Excision of the elbow, however, is usually a safe operation. In excising for deformity always consider the patient's trade and the demands of habitual position which it makes upon him.*

Excision is largely employed for joint-disease, especially for tuberculous joints. Bell states that attempts to preserve the limb without excision are more justifiable in the lower than in the upper limbs, because operation in the lower extremity is more dangerous than in the upper, and because a cure without operation in the lower limbs, if this cure can be brought about, gives as good a result as a cure by excision. In the upper extremities the danger from operation is less than is the danger from waiting. In a young subject an excision may remove the epiphysis, and thus lead to permanent shortening, which is productive of less inconvenience and deformity in the arm than in the leg. The great danger of excision operations is that the section may be made through cancellous bony tissue; hence disastrous suppuration, phlebitis, myelitis, septicemia, or pyemia may follow; further, in excision the cut is often made through diseased tissue, and a protracted convalescence is often inevitable. Amputation is effected through healthy tissue, and the convalescence is short. Excision, however, when successful, gives the patient a very useful limb.

Erasion, or Arthrectomy.—Erasion is the complete removal of diseased synovial membrane, ligaments, etc. This operation seeks to remove a depot of infection in an early stage of tuberculous synovitis, and it possesses the conspicuous merit of not interfering with the epiphysis. The term erasion is also used to designate the operation of removing healthy synovial membrane, ligaments, etc., for the purpose of producing fixation of a flail joint due to infantile paralysis. Erasion is oftenest practised upon the knee-joint. The instruments required are a scalpel, hemostatic forceps, dissecting forceps, toothed forceps, volsellum, scissors, bone-gouges, curets, and an Esmarch apparatus.

Erasion of the Knee-joint.—The patient lies upon his back; the leg is flexed with the sole of the foot planted upon the table, and an Esmarch ban-

* Joseph Bell, in his "Manual of Surgical Operations."

dage is applied at a point well up on the thigh. The surgeon stands to the right of the patient. The incision is begun in the mid-line of the thigh (on the side opposite to that occupied by the surgeon), about three inches above the patella; it is carried down across the ligament of the patella and up to a corresponding point on the opposite side of the thigh. This incision goes down to the bone; the flap is turned up and the joint exposed; the knee-joint is strongly flexed, and the synovial membrane and diseased ligaments are dissected away with scissors and forceps, great care being taken that the posterior ligaments (which, fortunately, are rarely implicated early

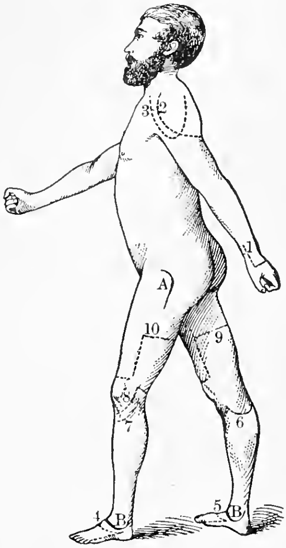


Fig. 334.

Fig. 335.

Fig. 334.—1–10, Amputations (Joseph Bell): 1, of lower third of forearm (Teale's); 2, at shoulder-joint by large postero-external flap (second method); 3, at shoulder-joint by triangular flap from deltoid (third method); 4, 5, through tarsus (Chopart's); 6, 7, at knee-joint; 8, by single flap (Carden's); 9, 10, of thigh (Teale's). A, excision of hip; B, of ankle-joint (Hancock's incision).

Fig. 335.—1–18, Amputations (Joseph Bell): 1, amputation at wrist-joint (dorsal incision); 2, at wrist-joint (palmar incision); 3, at forearm (dorsal incision); 4, at forearm (palmar incision); 5, at elbow-joint (anterior flap); 6, at arm (Teale's); 7, at shoulder-joint (first method); 8, 9, of metatarsus (Hey's); 10, 11, at ankle (Syme's); 12, 13, of leg, posterior flap (Lee's); 14, at knee-joint (Carden's); 15, of thigh (B. Bell's); 16, of thigh (Spence's); 17, of thigh in middle third; 18, at hip-joint. A, excision of wrist (radial incision); B, of wrist (ulnar incision).

in the case) are not divided and that the contents of the popliteal space remain intact. After removing the diseased ligaments and synovial membrane the cartilage is examined and any diseased portion is removed. The bone is then examined and any tuberculous foci are gouged away. Any exposed vessels are ligated. The wound is irrigated with salt solution, the extremity is straightened, and the ends of the ligamentum patellæ are sutured, a drainage-tube is inserted at each angle of the wound, the skin is sutured, and antiseptic or sterile dressings are applied. The limb is placed upon a posterior splint for a few days, then the drainage-tubes are removed, the dressings are changed, and a plaster-of-Paris cast is applied, trap-doors being cut on

each side, and the joint is kept immobile for two or three weeks. This operation is only suited to early cases in which the lesion involves chiefly or purely the synovial membrane and ligaments, and in these cases it frequently gives a good result, some capacity for motion being not unusually preserved.

Excision of the Shoulder-joint.—In the shoulder-joint *partial* excision is often performed, the head of the humerus being removed and the glenoid being undisturbed; but some patients require complete excision, the entire glenoid depression, as well as the head of the humerus, being removed by the surgeon. Excision of the shoulder-joint is made, if possible, an intra-

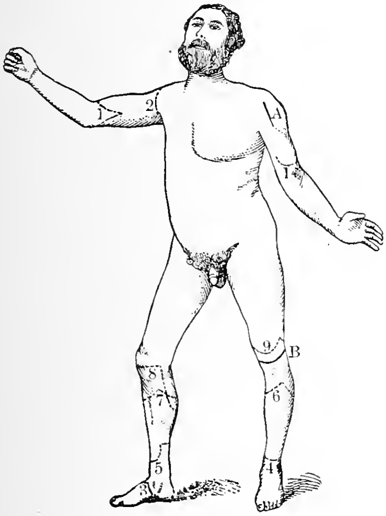


Fig. 336.

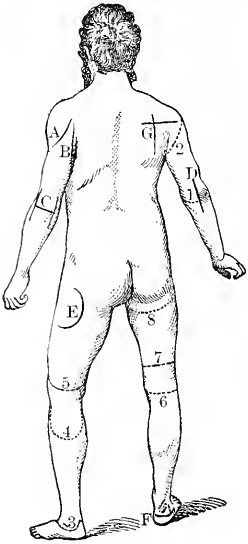


Fig. 337.

Fig. 336.—1–9, AMPUTATIONS (Joseph Bell): 1, of arm by double flaps; 2, at shoulder-joint; 3, at ankle-joint by internal flap (Mackenzie's); 4, 5, of leg just above the ankle-joint (Syme's); 6, 7, below the knee (modified circular); 8, through condyles of femur (Syme's); 9, at lower third of thigh (Syme's). A, excision of head of humerus; B, of knee-joint (semilunar incision).

Fig. 337.—1–8, AMPUTATIONS (Joseph Bell): 1, at elbow-joint (posterior flap); 2, at shoulder-joint, posterior incision (first method); 3, at ankle-joint (Mackenzie's); 4, through condyles of femur (Syme's); 5, at lower third of thigh (Syme's); 6, at knee (posterior incision); 7, of thigh (Spence's); 8, at hip-joint. A–C, Excisions: A, excision of shoulder-joint (deltoid flap); B, of shoulder-joint (posterior incision); C, of elbow-joint (H-shaped incision); D, of elbow-joint (linear incision); E, of hip-joint (Gross's); F, of os calcis; G, of scapula.

capsular operation, the capsule being opened, but the capsular attachment to the anatomical neck of the humerus not being interfered with. In advanced cases, however, the capsular attachment must be destroyed. Excision of the shoulder-joint is seldom performed in civil, but is a common operation in military practice; it is performed for gunshot-wounds, compound dislocations, tuberculous disease, and tumors of the head and upper portion of the humerus. The instruments required are a scalpel, an Adams saw and a metacarpal saw, an osteotome or chisel, a mallet, an Allis dissector, a periosteum-elevator, hemostatic forceps, dissecting forceps, toothed forceps, lion-jawed forceps, sequestrum forceps, metal retractors, curets, and cutting bone forceps.

Operation by Anterior Incision.—The patient lies supine; a pillow is placed beneath the shoulders, and a sand pillow is put beneath the shoulder to be operated upon. The arm is held to the side with the outer condyle forward and the bicipital groove inward (Barker's directions). The surgeon stands by the affected side. An incision three or four inches in length is made from just external to the coracoid process of the scapula, running straight down the humerus (Fig. 336, A). This incision divides the border of the deltoid muscle and brings into sight the long head of the biceps. The tendon of the biceps is retracted inward, unless it is diseased, in which case it is resected. The knife is carried up the groove and opens the capsule of the joint. The periosteum is lifted from the neck of the bone while an assistant rotates the elbow to make the muscles tense. In some places, if the periosteum tears, muscular insertions must be cut with a knife. The head of the bone is sawn off while the bone is in place, or the elbow is strongly pulled back, and the head of the bone is forced out of the wound, and is then sawn off at the point required. In ordinary cases only the articular head is removed; in other cases the section is made just above the surgical neck; in yet others a portion of the shaft must also be cut away. If the glenoid cavity is found slightly diseased, the dead bone must be removed by the chisel and mallet or by the cutting forceps. If the cavity is seriously diseased, the entire glenoid should be removed. Scrape away all damaged tissue; ligate bleeding points; irrigate the wound with corrosive sublimate solution; swab it out with a solution of chlorid of zinc (gr. xx to ℥j); dust with iodoform; close the upper portion of the wound and insert a drainage-tube in the lower angle; dress the wound antiseptically; place a small pad in the axilla; apply the second roller of Desault; and put the patient in bed with a pillow under the affected shoulder. In seven days the hand-sling is substituted for the bandage, and with the elbow hanging free the patient is permitted to get up and is advised to move his arm frequently. Drainage is maintained until the wound is well healed from the bottom. Great limitation of movement inevitably follows a shoulder-joint resection.

Excision by the deltoid flap is performed when the head of the bone is much enlarged (as by a tumor) or when the tissues are thick and indurated. The deltoid flap is in the shape of a U or is semilunar (Fig. 337, A). Raising this flap exposes the head of the bone most satisfactorily. Bell states that when the glenoid cavity is chiefly involved the incision should be posterior (Fig. 337, B).

Senn's Method.—Senn has recently described * an incision which does not damage any important vessels, muscles, tendons, or nerves, and which is followed by good functional results. A semilunar skin-flap is formed, the incision running from the coracoid process to the posterior border of the axillary space. The flap is turned up, exposing the upper half of the deltoid muscle. The acromion is sawn off and turned down with the attached deltoid. The capsule is now freely exposed; it is opened, and either arthrectomy or excision is performed, according to conditions. In closing the wound it is not necessary to bore the acromion and pass silver wires to join the fragments; it is enough to suture the periosteum with catgut.

Excision of the Elbow-joint.—This operation is performed for wounds,

* Phila. Med. Jour., Jan. 1, 1898.

faulty ankylosis, and chronic articular disease. Excision must be complete. Endeavor to make a subperiosteal resection; this maintains the shape of the articulation and gives the best chance for a movable joint. The instruments used are the same as those for the shoulder, plus a Butcher saw.

Operation.—The patient is "supine, but inclining to the sound side, the affected arm being held almost vertical, with the forearm flexed and nearly horizontal" (Barker). The incision is made on the posterior surface of the joint. A single posterior incision is usually employed (Fig. 337, D). An incision is made a little internal to the long axis of the olecranon, beginning two inches above and terminating two inches below the tip of the olecranon. This incision goes down to the bone, and throughout the entire operation the surgeon must guard and shield the ulnar nerve. The periosteum and soft parts are well separated; the olecranon is sawn off; forced flexion exposes the joint-cavity freely, and enables the surgeon to lift the periosteum and soft parts from the humerus; the humerus is sawn through at the beginning of its condyloid processes; the radius and ulna are cleared and are sawn at a level below that of the base of the coronoid process of the ulna. Diseased tissues are cut and scraped away; the wound is irrigated, sutured, drained, and dressed. In some cases an H-shaped incision is employed (Fig. 337, C), but the cicatrix of a transverse cut will limit flexion of the limb.

After excision of the elbow the patient is put to bed and the arm is laid upon a pillow, the elbow being placed midway between a right angle and complete extension, the forearm being placed midway between pronation and supination. No splint is used, as a rule. Esmarch used the splint shown in Fig. 338. The aim in treatment is to obtain a freely movable

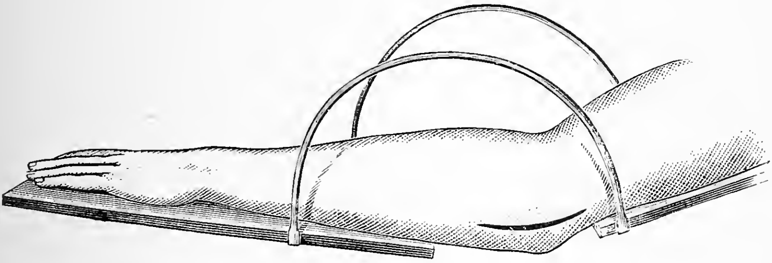


Fig. 338.—Esmarch's splint for the treatment of a limb after excision of the elbow-joint.

joint. Passive motion is begun in one week, at which time the patient gets up. The hand is carried in a sling for a time after healing of the wound is complete.

Excision of the Wrist-joint.—Bell states that, whatever method of excision is chosen, three cardinal rules must be borne in mind: (1) remove all the diseased bone, including the portions of the radius, ulna, carpus, and metacarpus which are covered with cartilage; (2) interfere with the tendons to the least possible degree; and (3) begin passive motion of the fingers very early. Many surgeons prefer the simple gouging away of diseased foci and the scraping of sinuses instead of a formal resection of the wrist, amputation being employed in severe cases or when scraping fails

after several trials. Formal excision is not frequently performed, and the results cannot be regarded as very favorable.

Lister's Open Method of Excision.—The instruments required in this operation are the same as those used for any resection. Break up adhesions as completely as possible by forcible movements. Apply a tourniquet or an Esmarch apparatus. The patient lies upon his back, the arm and the forearm being brought, from stage to stage, into the most desirable positions. Begin an incision over the middle of the dorsum of the radius, on a level with the styloid process: carry it downward in the direction of the inner edge of the articulation of the thumb with its metacarpal bone, and when the knife reaches the radial side of the second metacarpal bone alter the direction of the incision and carry it downward in the long axis of the metacarpal bone to about its middle (Fig. 335, A). This is known as the *radial incision,* and the only tendon divided is that of the extensor carpi radialis brevior muscle. The tissues upon the radial aspect of the incision are dissected up, the tendon of the extensor carpi radialis longior muscle is divided at its point of insertion (Bell), and all the soft structures are retracted outward, exposing the trapezium, which is cut off from the rest of the carpus, but which is left in place, as its removal at this stage endangers the radial artery (Barker). By extending the hand the tendons are loosened and the carpus is cleared in the direction of the ulnar border of the hand.

Another incision is made, starting upon the inner surface of the wrist, two inches above the articular surface of the ulna, and midway between the ulna and the flexor carpi ulnaris tendon. This incision, which is known as the *ulnar incision,* is carried down until it is opposite the middle of the fifth metacarpal bone in the palm (Fig. 335, B). "The dorsal lip of this incision is raised" (Bell), and the extensor carpi ulnaris tendon is divided and dissected from its depression, but is not separated from the integument. The extensor tendons are lifted; the ligaments upon the dorsum and sides of the wrist-joint are cut; the flexor tendons are raised from the carpal bones the pisiform bone is cut from the carpus, but is not yet removed; and the unciform process of the unciform bone is cut with forceps. The anterior radiocarpal ligament is divided, the carpometacarpal articulations are cu through, and the carpus is pulled out with bone-forceps. The ends of the radius and ulna are forced out of the ulnar incision. All that portion o the ulna which is crusted with cartilage is to be removed, the saw-cut is t be oblique, and the base of the styloid process is to be left behind. A thi section is to be sawn from the radius, and the tendon-grooves are not to b impinged upon. The articular surface of the ulna is cut away with plier (Bell). If foci of disease are discovered beyond these points, they are t be gouged out. The ends of the metacarpal bones are sawn off, and thei articular facets are cut away by means of pliers. The trapezium is dissecte out, the end of the first metacarpal bone is sawn off and its facet is cut awa with pliers, and a portion of the pisiform bone is removed (the entire bon being removed if it be diseased). The wound is irrigated, vessels are tied the radial incision is closed, the ulnar incision is partly closed, a drainage tube is inserted by way of the ulnar incision, the wounds are dressed ant septically, and the Esmarch apparatus is taken off. The forearm and han are placed upon a splint which immobilizes the wrist and leaves the finger

semiflexed. Passive motion of the fingers is begun after thirty-six hours. The splint is worn for many months, until the wrist-joint is immobile and solid. Esmarch uses the splint shown in Fig. 339.

Excision of Metacarpal Bones and of Phalanges.—Excision of a metacarpal bone, except in cases of necrosis with the formation of large

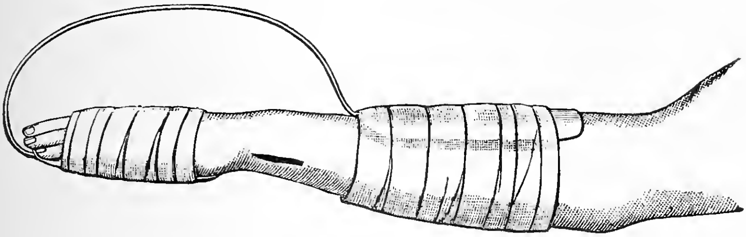


Fig. 339.—Esmarch's interrupted splint applied.

quantities of new bone, usually leaves a useless finger; hence amputation is preferred usually to excision. This rule does not apply to the metacarpal bone of the thumb, which is occasionally resected. The incision for this operation is made upon the dorsum, and is straight. Excision of the proximal phalanx of the thumb is sometimes performed. Excision for disease is rarely performed upon the finger-joints, amputation being preferred, though the operation is sometimes undertaken for compound dislocation. In the metacarpophalangeal joint of the thumb excision, if it can be performed, is preferred to amputation. The incision for resection of this joint is placed upon the radial aspect.

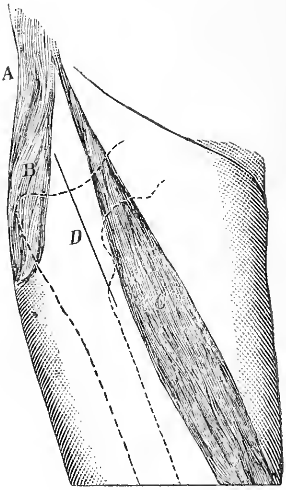


Fig. 340.—Excision of the hip-joint: A, Gluteus muscle; B, tensor vaginæ femoris muscle; C, sartorius muscle; D, anterior incision.

Excision of the Hip-joint.—Some surgeons advocate this operation; others, notably Marsh, are emphatically opposed to it. Excision should be performed in the early stage of tuberculous disease *if less radical treatment has failed.* In this stage the usual position of the limb is one of flexion, abduction, and eversion. In cases of long duration, especially where dislocation exists, excision is an easy and a comparatively safe operation; in recent cases it is difficult and carries with it decided dangers, but the peril of delay may be greater than the peril of an early resection. In cases of hip disease with involvement of the acetabulum the mortality is 50 per cent., whether operation is or is not attempted. Excision is performed especially for tuberculous disease and for gunshot-injuries. The instruments required are those used for other excisions.

Operation by Anterior Incision (Fig. 340) (Barker's Operation).—In this operation the patient is supine, with the thighs extended as thoroughly as circumstances permit. The surgeon stands to the right of the patient. An

incision is begun half an inch below and half an inch external to the anterior superior iliac spine, and it is carried downward and a little inward for about three inches (Fig. 340, D). If dislocation exists, the incision must not be so long. This incision is carried at once deeply between the muscles, and the capsule of the joint is opened. The neck of the bone is divided from its upper surface downward with a saw or an osteotome, and without dislocating the bone through the wound by forcible extension and eversion. The head of the bone is removed. All tuberculous foci must be scraped away, and the flushing gouge is used upon tuberculous areas of the acetabulum. All sinuses should be thoroughly scraped. Bleeding is arrested, the wound is irrigated with normal salt solution, mopped out with chlorid of zinc solution, and dusted with iodoform. A drainage-tube is inserted at the lower angle of the incision, and the upper portion of the cut is closed. The wound is dressed antiseptically. Extension is made with the extension apparatus until healing has obtained good headway, when a double Thomas's splint is applied, so that the patient can be taken out daily in the air and sunlight. As a rule, rigid ankylosis results from resection of the hip, but occasionally a joint results with a small range of movement.

Operation by Lateral Incision (Langenbeck's Operation).—In this operation a straight incision two inches long is made in the direction of the axis of the femur, and passing downward from the apex of the great trochanter. From the beginning of this incision a curved incision is carried toward the head of the bone, the convexity of the curve being backward (Fig. 334, A). Bell advises the use of the saw after bringing the head of the bone into the wound by abduction and eversion of the thigh. Barker applies the saw with the bone *in situ*, and strongly opposes wrenching the bone out of the incision, because of the danger of peeling off the periosteum, which peeling, if it takes place, favors necrosis.

Incision of Gross.—In Gross's operation a semilunar flap is made with the convexity backward (Fig. 337, E).

Excision of the Knee-joint.—In this operation a complete excision should be performed, and the patella ought to be removed. This operation is performed for tuberculous disease, some compound fractures and compound dislocations, and some cases of angular ankylosis, but it is rarely employed for gunshot-injuries, amputation being usually preferable. The instruments required are the same as those for the shoulder, plus Butcher's saw.

Operation by Anterior Semilunar Flap.—The patient lies upon his back, and the joint, if not ankylosed in extension, should be semiflexed. The surgeon stands to the right side. An incision is made which at once opens the joint. The incision begins at one condyle and reaches the other condyle by a curve which passes through the ligamentum patellæ midway between the tuberosity of the tibia and the inferior margin of the patella (Fig. 336, B). The flap is dissected up, the knee is thrown into forced flexion, the lateral ligaments and crucial ligaments are cut, and the end of the femur is well cleared. The blade of Butcher's saw is passed beneath the bone, which is sawn from below upward (Ashhurst). The end of the tibia is cleared and a portion is sawn off. If, after sawing, diseased foci are discovered, another section can be sawn off or

the foci can be gouged away. Ashhurst, who has had a vast experience with this operation, insists that in sawing through the femur the natural obliquity of the bone must be borne in mind and the section must be made in "a line parallel to that of the free surface of the condyles." If the section is made transverse to the axis of the femur, "the limb, after adjustment, will be found to be markedly bowed outward." The same surgeon says that the epiphyseal line is somewhat higher on the front than it is on the back of the femur, and in consequence the following rule is formulated for section of the condyles: the section of the condyles should be "in a plane which, as regards the axis of the femur, is oblique from behind forward, from below upward, and from within outward." Ashhurst advocates section of the tibia "in a plane transverse to the long axis of the bone, with a slight anteroposterior obliquity, so as to correspond with that of the section of the condyles," and he further says that the patella must be removed, whether it is diseased or not, and quotes Péniére's observations to the effect that excision of the patella diminishes the risk of death one-third, and its retention doubles the probability of an amputation becoming necessary in the future.

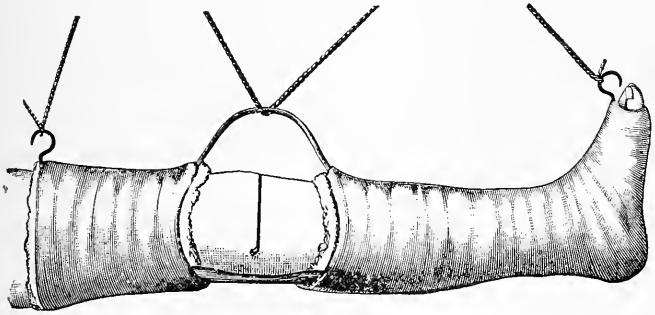


Fig. 341.—Watson's plaster-of-Paris swing-splint.

After removing the patella the diseased synovial membrane is clipped away with scissors and all sinuses and diseased territories are well curetted. The posterior ligament of the joint is not removed unless it is diseased; its retention prevents displacement and guards the popliteal space. In children the fragments should be wired together; in adults this need not be done. After hemostasis, irrigate, dust with iodoform, insert a drainage-tube, suture, dress antiseptically, and adjust the limb upon Price's splint or Ashhurst's bracketed wire splint. In some cases tenotomy is required to permit extension. Instead of the bracketed splint, a long fracture-box may be used. If the femur tends to project anteriorly, use an anterior splint. If there be a tendency to outward bowing, adopt Ashhurst's expedient of carrying a strip of adhesive plaster around the outside of the limb and fastening it to the inner side of the splint. The splint is kept on until bony union is complete, as in this operation a movable joint is never sought. Many surgeons use a plaster-of-Paris splint, which is employed until the parts have become firm and solid (Fig. 341).

Excision of the Ankle-joint.—This operation is performed chiefly for gunshot-wounds, compound dislocations, and in some cases of tuberculous

joint-disease. Excision of the ankle is an operation which is seldom performed. The instruments used are the same as those employed for any resection.

Operation (Hancock's Method).—In this operation the patient lies upon his back, the foot rests upon its inner side, and the surgeon stands to the outer side of the damaged limb. Begin an incision just behind and two inches above the external malleolus, and carry it across the front of the joint to a corresponding point above and behind the internal malleolus (Fig. 334, B); this incision goes only through the skin, and the flap thus marked out is reflected. "Cut down upon the external malleolus, carrying the knife close to the edge of the bone both behind and below the process, dislodge the peronei tendons, and divide the external lateral ligaments" (Joseph Bell). Cut the fibula one inch above the malleolus by means of pliers; divide the tibiofibular ligament; turn the foot upon its outer side; dissect from their habitat back of the inner malleolus the tendons of the posterior tibial and the common flexor of the toes; carry the knife around the inner malleolus, close to the bony edge; separate the internal lateral ligament, and dislocate

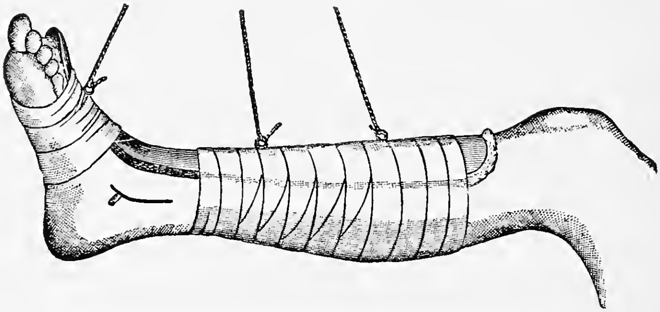


Fig. 342.—Volkmann's dorsal splint for excision of the ankle.

the lower end of the tibia through the wound by turning the sole of the foot downward; saw off the lower end of the tibia and the articular process of the astragalus, sawing away from the tendo Achillis, and remove the fragments with bone forceps. Cut away diseased synovial membrane, and curet all sinuses and tuberculous areas. Arrest bleeding, irrigate, and drain. Sew up the wound, insert a tube at the outer angle, and cause it to emerge at the inner angle. Apply antiseptic dressings, and put up the foot in fixed dressing or in splints at a right angle to the leg (Fig. 342). In Langenbeck's operation the excision is subperiosteal. If, in an excision of the ankle-joint, the astragalus is found extensively diseased, remove the entire bone.

Excision of the Os Calcis.—In caries limited to the os calcis most surgeons prefer to gouge away the dead bone, leaving the periosteum and, if possible, a shell of healthy bone, and draining thoroughly. Others advocate excision in some cases. Extensive disease limited purely to the os calcis is rare, and most surgeons advise gouging for limited caries, and Syme's amputation in the event of the disease extending beyond the periosteum or reaching adjacent bones.

Operation by Subperiosteal Method.—In this operation the position as-

sumed by the patient is supine with the leg extended and the foot resting on its inner side. The incision, which cuts the tendo Achillis and reaches the bone at once, is begun at the upper border of the os calcis and the inner margin of the tendo Achillis, and is taken outward and horizontally forward to a point in front of the calcaneocuboid articulation (Fig. 337, F). A vertical incision is begun near the forward termination of the initial incision, is carried across the outer edge and plantar surface of the foot, and terminates at the external margin of the inner surface of the os calcis. Some surgeons carry the vertical incision a little upward, toward the dorsum. The periosteum is entirely stripped with an elevator, the os calcis is removed, the cavity is packed with iodoform gauze, the wound is stitched, a drain is inserted posteriorly, and the foot is dressed antiseptically, is placed at a right angle to the leg, and plaster-of-Paris is applied, trap-doors being cut for drainage.

Astragalectomy, or excision of the astragalus, is seldom performed. Astragalectomy is employed occasionally for relapsed and inveterate cases of club-foot. The indications are pointed out by Willard ("International Clinics," vol. iii, 12th series): "(1) Adults with great bony deformity; (2) neglected children of five to fifteen years, who have markedly distorted their tarsi by locomotion; (3) relapsed cases which have resisted the milder forms of operation, or which have been neglected by parents after previous operation; (4) only occasionally, young children in whom from infancy the bones of the foot have been exceedingly rigid and unyielding, and where there is practically but little motion either at the ankle-joint or in the tarsus."

Operation by the Subperiosteal Plan.—Barker advises an incision going at once to the bone, from the "tip of the external malleolus forward and a little inward, curving toward the dorsum of the foot." The foot is extended and turned inward, the periosteum is lifted, the astragalus is removed, and the wound is treated and the foot is dressed as is done in excision of the os calcis.

Excision of the Metatarsophalangeal Articulation of the Great Toe.—In this operation make a lateral incision and cut off or saw off the proximal end of the first phalanx and the distal third of the first metatarsal bone.

Excision of the Metatarsal Bone of the Great Toe (Butcher's Method).—In this operation a lateral straight incision is made, the periosteum is elevated, and the shaft is sawn from each extremity and removed.

Excision of the clavicle may be required for dislocation, caries, necrosis, gunshot-wound, tumor of this bone, as a preliminary to ligation of the artery and vein in certain cases of amputation at the shoulder-joint, or in cases of removal of the entire upper extremity. In excision of the clavicle the position of the patient is the same as that for ligation of the third part of the subclavian artery (page 410). An incision is made down to the bone, from the sternoclavicular joint to the acromioclavicular articulation. If the case is suitable, the periosteum is stripped and the bone is sawn and removed; if not, the bone is sawn and each half is separately disarticulated. The wound is sutured and dressed, and the limb is put up in a Velpeau bandage.

Excision of the Scapula.—Complete excision of the scapula is usually performed for tumors. Partial excision requires no detailed description.

In excision of the scapula the patient lies upon his sound side. Treves suggests the following incisions: one outside the vertebral border of the scapula, from its superior to its inferior angle; another from over the acromioclavicular joint, along the acromion process and spine of the scapula, to meet the first incision. Syme used an incision carried transversely inward from the acromion process to the vertebral border of the scapula, and another cut directly downward from the center of the first incision (Fig. 337, G). In the method of Treves* the upper flap is reflected and the trapezius muscle is divided; the lower flap is reflected and the deltoid muscle is divided. The patient's hand is placed on the sound shoulder; the muscles of the vertebral border are divided, the posterior scapular artery is tied, and while the vertebral border of the scapula is pulled toward the surgeon, the serratus magnus muscle is cut, the upper border of the shoulder-blade is cleared, and the suprascapular artery is tied. The hand is now brought down to the side; the acromioclavicular joint is disarticulated; the conoid and trapezoid ligaments are divided; the muscles of the coracoid process are cut; the capsule is incised, with the supraspinatus and infraspinatus, the subscapularis, and the scapular origins of the biceps and triceps muscles; and finally the teres major and minor muscles are divided, the subscapular artery is tied, and the bone is removed. The wound is stitched, a drain is introduced, and antiseptic dressings are applied. The patient lies upon his back until healing is well under way, when the arm is placed in a sling. The drainage-tube may be removed in twenty-four hours.

Excision or Resection of a Rib (Fig. 427).—In *caries* the gouge and rongeur may remove the disease. In other cases excision is performed. In this operation the patient lies upon his sound side unless the operation is performed for empyema, in which case he lies on his back or only partly on the sound side. (See Empyema, Operation for.) The surgeon faces the patient. Make an incision down to the bone, in the long axis of the rib. The periosteum, if not diseased, is lifted from the bone, and the intercostal artery is lifted out of the way with the periosteum and is thus saved from being cut. After dividing the bone beyond the limits of disease, remove it. During the sawing a metal retractor is held beneath the rib, between the rib and the periosteum. It is better to saw it than cut it with ordinary biting forceps, because the latter splinter the bone. The author usually uses a forceps known as a *costotome*, which cuts the rib without splintering. If the periosteum is diseased, remove it after tying the intercostal artery. It should be removed in a case of empyema, otherwise bone-formation may interfere with drainage. In *empyema*, after removing the periosteum, open into the pleural cavity, allow pus to flow out slowly, remove fibrinous masses, employ a finger to feel if there are adhesions and if the lung will probably expand, and insert a drainage-tube. In resection for rib disease curet sinuses and pack with iodoform gauze for some days. Sew up the wound except at one end. Dress antiseptically and apply a binder. (See Operations upon the Chest and Estlander's Operation.)

In *removing a cervical rib* make an incision along the posterior edge of the sternocleidomastoid, avoid the pleura, subclavian vessels, and brachial plexus, and remove the periosteum with the rib in order that the bone will not be reproduced.

Complete Excision of One-half of the Upper Jaw.—The whole upper

*Treves's "Manual of Operative Surgery."

jaw has been removed, but in what follows only resection of one-half the jaw will be described. This operation is performed for malignant tumors of the superior maxillary bone or its antrum. Up to 1826, at which time Lizars, of Edinburgh, suggested the operation, tumors of the antrum were treated by scraping them away with a sharp spoon. Gensoul, of Lyons, in 1827 performed the first operation for resection of the upper jaw. This operation is not justifiable, except as a palliative measure, if the orbit is invaded, if the skin and subcutaneous tissues are infiltrated, or if the disease extends widely beyond the superior maxillary and palate bones. The instruments required are: a mouth-gag; scalpels; strong scissors; tracheotomy tubes; dissecting, toothed, and hemostatic forceps; bone-cutting, lion-jaw, sequestrum, and tooth-extracting forceps; a volsella; a narrow-bladed saw; a chisel and mallet; a periosteum-elevator; a spatula or metal retractor; Paquelin's cautery; sponges which are tied to sticks; needles, curved and straight, large and small; silk and catgut ligatures; silkworm-gut sutures; and Horsley's antiseptic bone-wax.

Fig. 343.—*A B*, Incision of the soft parts preliminary to excision of the upper jaw; *C D E*, incision of soft parts preliminary to excision of the lower jaw.

Preliminary Closure of the External Carotid Artery.—Some surgeons ligate the external carotid artery or compress it temporarily. In a number of excisions of the upper jaw I have always found the hemorrhage readily controllable as soon as the bone is removed, and have never felt it necessary to resort to preliminary ligation or compression.

Fig. 344.—1, Excision of the upper jaw: A B, Section of the nasal process; B C, section of the orbital plate; D, section of the malar bone and orbital plate; E, section of the alveolus and hard palate. 2, Excision of the lower jaw: G, Section of the inferior maxillary; H, section of the ramus in partial resection.

Operation by Median Incision.—The patient, whose face has been shaved, is placed in the Trendelenburg position, thus avoiding the possible need of instant tracheotomy. The surgeon stands to the right side of, and faces, the patient. The incisor tooth on the diseased side is pulled out. The incision, which is known as Weber's incision (Fig. 343, line A B), is begun half an inch below the inner canthus of the eye, and is carried along the side of the nose, around the ala of the nose, by the margin of the nostril, and through the middle of the lip. While the lip is being incised the assistant arrests hemorrhage by grasping the corners of the mouth, and after the lip is divided, the coronary arteries are at once ligated. Some operators approach the mucous membrane cautiously and ligate the vessels before opening the cavity of the mouth. The upper portion of the wound having been compressed by another assistant during these manipulations, pressure is now removed and bleeding points are ligated. Another incision is now carried outward from the beginning of the first incision, along

the orbital margin to well over the malar bone. The flap is lifted from the periosteum, and the bleeding from the infraorbital artery and the small vessels is restrained by pressure. The nasal cartilage is separated from the bone, and the nasal process of the superior maxillary is sawn (line A B, Fig. 344). The orbital periosteum is lifted up, and the orbital plate is cut with forceps from the saw-cut in the superior maxillary bone to the sphenomaxillary fissure (line B C, Fig. 344). The malar bone is sawn or is bitten through about its center, the cut running into the sphenomaxillary fissure and taking a downward and outward direction (line C D, Fig. 344). The soft parts covering the hard palate are incised in the median line, a corresponding incision is made along the floor of the nose near the septum, and the soft palate is separated from the hard palate by a transverse cut. The saw is introduced through the nose, and the palate is sawn (line E, Fig. 344). The upper jaw-bone is grasped with Fergusson's lion-jaw forceps and removed, the removal being aided by the use of the scissors and bone-cutters; the latter are used to separate the upper jaw from the pterygoid process (Treves). Every vessel that can be seen is tied, and severe bleeding from bone is arrested by antiseptic wax. Oozing is controlled by hot water and pressure or by Paquelin's cautery. Examine carefully to see if all the diseased area is removed; if it is not, use the gouge, scissors, chisel, and saw until healthy tissue is reached. The wound is packed with iodoform gauze, and the end of the strip is so placed as to be accessible through the mouth. The wound is sutured (the mucous membrane of the lip must be stitched, as well as the skin) and is dressed antiseptically (the eye being protected by aseptic gauze), and a crossed bandage of the angle of the jaw is applied.

Excision of One-half of the Lower Jaw.—In some rare instances the entire inferior maxillary bone is removed. The lesions necessitating removal of the lower jaw are of the same nature as cause us to remove the upper jaw. The instruments required for removal of the lower jaw are those used for excision of the upper jaw, plus a metacarpal saw (having a movable back).

In this operation the patient is placed in the same position as for excision of the upper jaw, the chin having been previously shaved. A vertical cut is made through the chin-tissue, starting below the margin of the lip and reaching to below the border of the jaw (C D, Fig. 343). From the point D an incision is carried outward below the border of the jaw and then back of the ramus, as shown in the line D E (Fig. 343). Treves's advice is to carry this incision down to the bone, except at the line of the facial artery, at which point it must go through the skin only. The facial artery is now to be sought for, tied in two places, and divided. The periosteum is lifted from the external surface of the bone, from the symphysis outward. Hemorrhage is arrested. The buccal mucous membrane is cut from the alveolus. A lateral incisor tooth is pulled, and the bone is sawn in the line G (Fig. 344). The bone is grasped in a lion-jaw forceps and is drawn outward. The mylohyoid insertion is cut; the internal pterygoid muscle is cut or the periosteum at this spot is lifted; the inferior dental artery is cut and tied; the jaw is pulled down; the insertion of the temporal muscle upon the coronoid process is cut away; and the external pterygoid muscle is divided. The capsule of the joint is opened, and the bone is separated from the ligaments which still

hold it in place. Bleeding is arrested, the wound is sutured, a tube is introduced in the posterior portion of the wound and retained for twenty-four hours, and antiseptic dressings and a Gibson or a Barton bandage are applied. Partial excisions of the alveolus may be performed through the mouth by means of chisels and rongeur forceps, and Wyeth has thus removed half of the jaw; but if any considerable part of the body of the jaw is to be removed, it is usually best to make an incision below the inferior maxillary.

Barker's Operation for Dislocation of the Semilunar Cartilages of the Knee-joint.*—Begin the incision over the ligament of the patella, half an inch above the articular surface of the tibia, and carry it in a curve downward and outward to the anterior edge of the internal lateral ligament. The periosteum should be divided by the cut. This incision forms a flap the lower edge of which is half an inch below the border of the articular surface of the tibia. The flap is lifted until the cartilage is seen "under the attachment of the meniscus, which if partially attached will rise with the flap until its under surface is seen." If partially torn anteriorly it is stitched to periosteum by a few silk sutures. The periosteum is then stitched in place, no drain is used, the joint is immobilized, and for one week ice is kept upon the part. If the meniscus is found completely separated and curled up, it may, if the injury was recent, be reduced. If the injury was old and if the cartilage is shrunken, it should be completely cut away (Barker).

Operation for Congenital Dislocation of Hip.—*Lorenz's Bloodless Method of Reduction.*—The method of reducing by manipulation a congenital dislocation of the hip was devised by Paci and modified and improved by Lorenz. It has long been known that reduction is easy at birth, because an acetabulum, though probably a shallow one, exists and the head of the bone is not firmly held in its new situation. In an older child the problem is far more difficult, because, even if reduction is effected, the acetabulum may be extremely shallow or absent, and redislocation may readily occur. Lorenz aims to effect thorough reduction and then fixes the limb in abduction for months, so that the acetabulum will deepen and the bone will become firm in its proper socket. This operation is rarely successful in children over six years of age. The child is anesthetized and an attempt is made to draw the femoral head on to a line with the acetabulum. If the child has never walked, this is readily accomplished. If it has walked, the procedure may be very difficult, and it may be necessary to make extension with a fillet fastened above the knee, and counter-extension with a screw and a perineal band. The drawing down of the head is made easier by stretching and massaging the adductor muscles. The next step is to strongly flex the thigh, rotate it a trifle internally, and then abduct it while flexion is maintained. This causes the head of the femur to pass around the posterior margin of the acetabulum and frequently produces reduction. "Full abduction being kept up, the thigh is rotated out, thus forcing the head of the femur more firmly into the socket" (see the description of the Lorenz method in J. Jackson Clarke's "Orthopædic Surgery"). The strongly abducted limb is put up in plaster-of-Paris. In about three months the plaster is removed, the abduction is diminished, the plaster is reapplied and is retained for another three months. During the continuance of immobilization of the hip, the child

* "Lancet," Jan. 4, 1902.

walks about, with the knees bent. When the plaster is finally removed, manipulation, massage, and exercise strengthen the muscles and give freedom to the joint. In a double dislocation one joint can be cured before the other is operated upon, or both may be operated upon at the same séance. In double dislocation plaster must be worn more than six months. The Lorenz operation is safe when applied to very young children, but has elements of danger which increase with the years of the subject. A patient may suffer grave lacerations of muscles and ligaments, and even vessels and nerves. Death may result from shock, and extensive deep-seated hemorrhage may occur. In fact, it is a mistake to call it a bloodless method. The blood flows, though we do not see it. An untrained man may do fearful mischief by this operation, and it should only be attempted by a very skilful manipulator and upon properly selected cases, when it is a very successful procedure. I am satisfied that, except in the case of a very young child, in whom reduction is easy, one who performs the Lorenz operation should be something more than skilful and experienced. He should be physically strong, so that traction and abduction will be powerful and steady. A weak man will jerk, will throw his weight upon the part, and will be apt to tear structures instead of stretching them. Sudden forcible movements are apt to break the bone.

Hoffa's Operation.—The instruments used are the same as for a resection. Make the external incision of Langenbeck to open the joint (page 628). The capsule is incised at its insertion into the neck, and the periosteum and muscles are lifted from the great trochanter. Hoffa claims that in children less than five years of age the head of the bone can be readily replaced into the acetabulum by flexing the thigh and making direct pressure upon the head of the bone. After replacing the femoral head it is held in place while an assistant extends the leg in order to stretch the muscles. In children over five years of age cut the muscles which spring from the ischial tuberosity and also the adductors with a tenotome; cut the fascia lata and muscles which arise from the anterior superior iliac spine by incision; open the joint and liberate the head of the bone; remove the ligamentum teres; scrape out the acetabulum, removing "cartilage, fat, and considerable spongy tissue" (Tubby); and replace the head of the bone in the acetabulum. The limb is maintained in inversion, abduction, and extension for several weeks, when it is straightened. Massage and passive motion are begun in the fifth week. The patient now gets about, wearing an apparatus for many weeks. This apparatus permits the head of the bone to move in the socket, but prevents redislocation.

Lorenz's Operation.—This is a modification of Hoffa's. The muscles inserted into the greater and the lesser trochanter are not cut; the sartorius, the hamstrings, and the external portion of the fascia lata are cut (Tubby).

The incision of Lorenz is longitudinally from the anterior superior spine. Another incision is carried inward from this at the level of the lesser trochanter. The capsule is opened by a crucial cut; the acetabulum is enlarged; the head of the bone, if it remains, is inserted into the acetabulum; if there is no true head, a new one is formed and inserted into the cavity. The limb is immobilized in a position of moderate abduction. Massage and passive motion are begun in the fifth week, and are continued for months.*

* I have drawn upon the very lucid description of these operations in A. H. Tubby's treatise upon "Deformities."

XX. DISEASES AND INJURIES OF MUSCLES, TENDONS, AND BURSÆ.

Myalgia, or **muscular rheumatism,** is a painful disorder of the voluntary muscles and of the fibrous and periosteal areas where they are attached. The term "muscular rheumatism" is not strictly correct. It is possible that in some cases the muscular structure is inflamed, but it is certain that in many cases the pain is distinctly neuralgic. Muscular rheumatism may be due to cold and wet, to over-exertion and strain, to acute infectious disorders, to syphilis, to chronic intoxications (lead, mercury, and alcohol), and to disturbances of the circulation. Gouty and rheumatic persons are especially predisposed, men being more liable to the disease than women. The disease is usually acute, but it may be chronic.

Symptoms.—Muscular rheumatism is apt to come on suddenly. The pain, which may be very acute and lancinating or may be dull and aching, is in some cases constantly present; in other cases it is awakened only by muscular contraction, and it is frequently relieved by pressure, though there is often some soreness. The skin above the muscle is sometimes tender to light pressure. The disease usually lasts for a few days, but it tends to recur. There is little, if any, fever.

Lumbago is myalgia of the muscles of the loins. *Rheumatic torticollis* is myalgia of the muscles of the neck. Usually one side of the neck is attacked. The chin is turned from the affected side and the neck is stiff. *Pleurodynia* is myalgia of the intercostal muscles. The pain is very severe, is aggravated by deep respiration, by coughing, and by yawning, there may be tenderness, and the patient tries to limit chest-movement. In *intercostal neuralgia* the pain is limited, is not constant, but occurs in distinct paroxysms, and is linked with the presence of the tender spots of Valleix. Pleurodynia lacks the physical signs of pleurisy. *Cephalodynia* is myalgia of the muscles of the scalp. The muscles of the shoulder, upper dorsal region, abdomen, and extremities may also be attacked by myalgia. Myalgia must not be confused with the pains of locomotor ataxia.

Treatment.—Remove any obvious cause. Treat any existing diathesis, such as gout or rheumatism. Rest is of the first importance. For lumbago, put the person to bed. For pleurodynia, strap the side of the chest. A hypodermatic injection of morphin and atropin into the affected muscles at once allays the pain, and a deep injection of distilled water is sometimes curative. Relief may be afforded by painting the surface with 30 drops of a mixture of equal parts of guaiacol and glycerin and covering the painted area with cotton. The introduction of four or five aseptic needles into the muscles, and their retention for a few minutes, sometimes act most favorably. Ironing the skin above the painful muscles with a very warm iron, a piece of flannel being interposed, is a useful domestic remedy. Vigorous rubbing of the area with a piece of ice allays the pain. Hot poultices do good. If the pain is widely diffused, alters its seat, or is very obstinate, order hot baths or Turkish baths and administer diuretics. In chronic cases employ blisters or counter-irritation by the cautery, give iodid of potassium and nux vomica, and have the patient take a Turkish bath every week. The

constant electric current finds advocates. In an ordinary severe case order a hot bath, put the patient to bed with a hot-water bag over the part, and administer 10 grains of Dover's powder; the next morning order to be taken four times daily a capsule containing 5 grains of salol and 3 grains of phenacetin, until the pain disappears. Citrate of potassium, citrate of lithium, chlorid of ammonium, or the salicylate of colchicin may be ordered instead of salol and phenacetin.

Infective myositis is a wide-spread inflammation of the voluntary muscles, due to an unknown infective cause. It is a disorder accompanied by pain and stiffness, by cutaneous edema, and by various paresthesiæ. Myositis resembles trichinosis, and is distinguished from it only by spearing out a bit of muscle and examining it microscopically. Occasionally diffuse suppuration occurs.

Ordinary myositis arises from injuries, from syphilis, or from rheumatism, and it presents the usual inflammatory symptoms. Contraction and adhesions may follow. I operated upon a case of myositis of the rectus abdominis in a boy of eight. There was a large mass like a full bladder. There had not been an attack of typhoid and there was not hereditary syphilis. Caseation existed. The condition was possibly tuberculous, although no bacilli were found.

Treatment of Myositis.—Infective myositis is treated by anodynes, stimulants, nutritious food, hot applications, and rest. If pus forms, it should be evacuated. Rheumatic myositis calls for the administration of the salicylates, the alkalies, or salol. Syphilitic myositis is treated with mercury and iodid of potassium. The remedies employed for myalgia are used in traumatic myositis.

Hypertrophy of the muscles may arise from their increased use. In *pseudohypertrophic paralysis* the bulk of the muscle is greatly augmented, but it contains less muscle-structure and more fat or connective tissue.

Atrophy of the muscles arises from want of use, from injury, from continuous pressure, from interference with the blood-supply, from disease of the nerves or their centers, or from lead-poisoning.

Degeneration of Muscles.—The muscles may undergo granular degeneration, waxy degeneration, fatty degeneration, and calcareous degeneration, and may become pigmented.

Local Ossification and Myositis Ossificans.—It is not unusual for a small portion of bone to form in the periosteal insertion of a muscle which is subjected to frequent strain. In persons who ride many hours a day there not infrequently develops the "*rider's bone*," which is an area of ossification in the adductor muscles of the thigh. *Myositis ossificans*, a wide-spread ossification of the muscles, is a rare disorder the cause of which is unknown, and which, if not congenital, at least begins in early life. In some cases a traumatic origin seems probable. It is seen more often among males than females. Columns of inflammatory swelling and induration slowly develop, each column running in the direction of the muscular fibers, and ossification of the indurated columns takes place. It is stated that the thumbs and great toes shorten (J. Jackson Clarke's "Orthopædic Surgery").

Tumors of the Muscles.—Primary tumors of the muscles are rare. Among those which may occur are sarcoma, fibroma, lipoma, osteoma,

angioma, myxoma, and enchondroma. Most cases of supposed primary sarcoma of muscle are in reality cases of syphiloma (Esmarch).

Syphilis may cause inflammation. Gummata may form, or gummatous infiltration may take place.

Trichinosis or **trichiniasis** is a disease due to the embryos of the trichina spiralis. The disease originates from eating meat which contains the trichinæ and has been insufficiently cooked. These nematodes are carried into the intestine, there to develop and multiply. In from seven to nine days a horde of embryos develop in the bowel, and leave the alimentary canal by passing through the peritoneum or by means of the blood, and finally reach the connective tissue of the muscles. From the connective tissue the embryos migrate into the primitive muscle-fibers, where they dwell and enlarge. Myositis develops, and in the course of five or six weeks the parasites become encapsuled and develop no further. The cyst-walls may calcify and the worms may become calcified, or may live for years. The eating of infected meat is not inevitably followed by the disease, and a few embryos lodged in muscle may cause no symptoms.

Symptoms.—The symptoms of trichinosis often appear in a day or two after eating infected meat. The symptoms of acute gastro-intestinal catarrh or of cholera morbus are common, but in some cases no gastro-intestinal manifestations usher in the disease. In from seven to fourteen days after the infected meat is eaten the migration of the parasites develops obvious symptoms. A chill may be noted; there is usually fever; muscular pain, tenderness, swelling, and stiffness are complained of. This condition may be wide-spread. Involvement of the muscles of mastication interferes with chewing; of the larynx, with talking and respiration; of the intercostals and diaphragm, with respiration. Skin-edema and itching are marked. In some cases delirium exists. The writer saw in the Philadelphia Hospital one fatal case which was mistaken for erysipelas because of the high fever, the delirium, and the edematous redness of the face and neck. Dyspnea is frequent. Mild cases get well in a week or two; severe cases may last many weeks. The mortality varies in different epidemics from 1 to 30 per cent. (Osler). The diagnosis is made by spearing out a piece of muscle, which is then examined for trichinæ under a microscope; or the worms may perhaps be detected in the feces by means of a pocket-lens. In a case under the care of the author, in St. Joseph's Hospital, there was no record of any attack of gastro-intestinal disturbance and the first manifestation was enlargement of the calf of the left leg. In most cases of trichinosis there is eosinophilia, but in the author's case, previously referred to, eosinophilia was not present.

Treatment.—To treat trichinosis employ purgatives (senna and calomel) early in the case, and give glycerin, and also santonin or filix mas. When muscular invasion has taken place, sedatives, hypnotics, nourishing diet, and stimulants are indicated.

Ischemic Myositis, or Volkmann's Contracture (*Volkmann's paralysis; Ischemic paralysis; Ischemic muscular atrophy* with contractures and paralysis, Fergusson calls it).—It is occasionally noticed, particularly in children, that after prolonged fixation of the forearm, especially after prolonged fixation of the elbow-joint, by some appliance that impedes the freedom of circulation in the part, contraction of the fingers occurs, or

possibly rigidity and contraction of the wrist. The same condition may come on after a severe injury in the neighborhood of the elbow-joint, may follow ligation of the main artery of a limb, venous embolism, venous thrombosis from injury or infectious disease, Raynaud's disease, or cold. There are two forms, one due to almost complete arterial ischemia lasting for several hours at least; another due to interference with venous return. Volkmann's contracture is due to a muscular degeneration, infiltration, induration, and contraction, the result of marked and prolonged arterial ischemia or interrupted venous return, and it is frequently spoken of as ischemic myositis (Dudgeon, "Lancet," Jan. 11, 1902). In some cases distinct neuritis with paralysis also exists. One characteristic of ischemic contracture is the rapidity with which it comes on. Dudgeon points out that in half a day, or even in less time in some cases, the symptoms appear, these symptoms being paralysis of the part with contracture. Pain is unusual, unless the nerves are seriously involved. In some cases the fingers and hand swell and become discolored. The absence of pain frequently prevents the recognition of the condition; therefore, the causative splint or bandage pressure may be maintained for days after the trouble has become serious. When the splints and bandages are removed and the forearm is examined, there is almost always tenderness over the muscles and the nerve-trunks; and in the majority of cases in which a splint was the cause, a portion of the skin will have sloughed. Dudgeon points out the characteristic position of the deformity, as follows: When the wrist is extended, the metacarpophalangeal joints are also extended; but the interphalangeal joints of the fingers and the terminal joint of the thumb are so strongly bent that the tips of the fingers touch the palm, and this position cannot be corrected by any justifiable amount of force. As soon as the wrist-joint is bent to a right angle, the interphalangeal joints can readily be extended. In a very severe case the wrist itself will become markedly flexed, and it will be impossible to extend it. The forearm is usually semiflexed and the hand pronated. The ulceration or sloughing so frequently present is called a *splint-sore*. There is always marked induration about a splint-sore. The flexor muscles themselves are indurated and usually wasted. The condition of sensation depends upon the state of the nerves of the part. When neuritis is absent, sensation will be normal; but in accordance with the amount of neuritis and degeneration there will be hyperesthesia, partial anesthesia, or complete anesthesia. A curious feature of these cases that is dwelt upon by Dudgeon and commented upon by Turner is the fact that in young children there is a cessation of growth of the bone.

Treatment.—The old view of this condition was that it is practically hopeless. Anderson and Dudgeon, however, maintain that restoration may usually be obtained, the treatment consisting in regular, active motion, passive movement, massage, and electricity. Extension under ether is of no benefit whatever. In a persistent and long-continued case an operation may be necessary. The operation may consist in dividing in the forearm the flexor muscles of the fingers, as advised by Davies Colley, and then, at a later period, dividing the flexor tendons. The objection to his procedure is that it destroys the capacity to flex the fingers for all time. Another suggestion has been to excise a piece from both the radius and the ulna, and wire the fragments together. The best surgical treatment is probably exposing the nerves, separating them from adhesions, stretching them, and then doing tendon-lengthening, but this should

not be done until all the improvement possible to secure by conservative treatment has been obtained by at least three months of effort.

Wounds and Contusions of the Muscles.—*Wounds* of muscles may be either *open* or *subcutaneous*. In a longitudinal wound the edges lie close together, and hence drainage must be provided for by the surgeon. In a transverse wound the edges separate widely, and catgut stitches must be inserted. *Contusions* of muscles, like contusions of other tissues, vary in extent and in severity. There are pain (which is increased by attempts to use the muscle), loss of function, swelling beneath the deep fascia, and discoloration, which may appear at once because of superficial damage from the initial injury, or which may appear in dependent parts after many days by gravitation of the blood and the blood-stained serum. As a result of contusion, suppuration, inflammation, or atrophy may arise.

Treatment.—In a longitudinal wound, drain; in a transverse wound, suture the muscle. The further indications in wounds and contusions of muscles are to obtain rest by means of splints and to secure relaxation. Limitation of swelling is secured by bandaging. Inflammation is combated first by cold and lead-water and laudanum; later by iodin, blue ointment, ichthyol, and intermittent heat. To prevent loss of function, employ, as soon as the acute symptoms subside, massage, passive motion, and stimulating liniments, and, later in the case, electricity (galvanism if the reactions of degeneration exist; faradism, if absent).

Strains.—A strain is a stretching of a muscle with a small amount of rupture. The muscle is swollen, tender, stiff, weak, and sore, and attempts at motion produce sharp pain. Strains are common in the deltoid, the hamstring muscles, the back, the calf, the biceps, and the great pectoral. *Strain of the psoas muscle* causes pain on voluntary flexion of the thigh, and is associated with tenderness in the iliac fossa. Strain of the right psoas may be mistaken for appendicitis, but it lacks the intense local tenderness, the abdominal rigidity, and the constitutional symptoms. "*Lawn-tennis arm*" is a strain of the pronator radii teres muscle. "*Riders' leg*" is a strain of the adductor muscles of the thigh. A strain may be the only injury, or may be associated with some other condition (fracture of bone, dislocation, sprain, contusion, etc.). A strain may be followed by periostitis at the point of insertion of the muscle.

The muscle is often rigid, is tender, and pains greatly when an attempt is made to use it. The skin over it, especially over its point of insertion, is usually tender.

A *strain of the back* is a very common accident which is often associated with sprains of the vertebral articulations. There is great pain when the patient voluntarily straightens up. If the vertebral ligaments are not damaged, the patient can be straightened by passive motion without pain. The skin is tender in certain areas. The muscles are often rigid. There may be unilateral rigidity. In a back injury make a careful examination to be sure no damage has been inflicted upon the vertebræ or cord.

Treatment.—Relaxation by suitable position; rest by the use of splints or by putting the patient to bed; bandages for compression; hot fomentations or a hot-water bag, and ichthyol. As soon as acute symptoms subside employ frictions and massage. If there is much pain after a strain, administer Dover's powder, or even morphin.

Rupture of Muscles and Tendons.—Rupture of a muscle is announced by a sudden and violent pain and by loss of function arising during powerful muscular contraction or strong traction on a muscle. The rupture may be announced by a clearly audible snap (A. Pearce Gould). A distinct gap is felt between the ends; great pain develops on movement; there are tenderness, loss of power, and swelling. Strains and ruptures may be followed by atrophy, as are contusions. Among the muscles which occasionally rupture we may mention the quadriceps, biceps, triceps, deltoid, plantaris, etc.

Rupture of the biceps flexor cubiti or its tendon is not very common; 72 cases have been reported (W. W. Keen, in "Annals of Surgery," May, 1905). The rupture may be where the muscular belly passes into the lower tendon, through the muscular belly, in the muscular part passing either to the long or short head or at the part where the muscular belly joins the long or short head. The tendon of the long head may be torn through or the long head may be torn from the glenoid cavity. The muscular portion is far more often injured than the tendinous. In rupture of the muscle belly a part of the muscle, in rupture of the long head the entire muscle, becomes soft and relaxed. In rupture of the belly there is a gap between the two portions and each portion causes a lump. In rupture of the tendon there are not two lumps with a gap between, but there will be a single muscular lump. In rupture of the long head the muscular belly is much nearer the elbow than in health (Figs. 345 and 346). If rupture takes place at the lower part of the belly, the muscle passes toward the shoulder. *Rupture of the long head of the biceps* allows the humerus to pass somewhat forward and upward.

Flexion with the forearm supinated is much less powerful than flexion with the forearm pronated (*Hüter's sign*).

In a case of my own in the Blockley Hospital the accident had occurred while carrying a heavy bucket. Forearm flexion was possible, but slow, feeble, partial, and incomplete. On flexion the short head contracted, but the muscular "bunch" of the belly was nearer the elbow than normally. *Rupture of the plantaris muscle* (*coup de fouet; lawn-tennis leg*) is an injury which is frequently not diagnosticated. It occurs during exercise (walking, bicycling, jumping, playing tennis) or is first complained of after exercise. It produces sudden pain in the middle of the calf, swelling, and often ecchymosis and inability to walk except with a rigid ankle and everted toes. *Rupture of the quadriceps extensor femoris tendon* results occasionally from force which in other cases fractures the patella. The rupture is just above the patella. The patient cannot extend the thigh and cannot walk or stand and there is severe pain. A gap can be felt just above the patella, unless it is hidden by synovial effusion, and the muscle is bunched above.

Treatment.—In limited rupture treat as a severe strain. In treating extensive rupture of an important muscle, when the ends are widely separated, expose by a septic incision, unite the divided ends with sutures of chronicized catgut (Fig. 91), and sew up the skin with silkworm-gut. Treat the part in any case by rest and relaxation and combat inflammation by appropriate means. Passive motion and massage are employed as soon as union is firm. In rupture of the quadriceps extensor femoris, operation should be undertaken, because mechanical treatment gives frequently a bad result and confines the

patient to bed for weeks. *Rupture of the biceps* requires incision and suture. In a case in the Blockley Hospital (Figs. 345 and 346) I operated and found that the long head with a portion of periosteum had been torn off from the glenoid cavity. A portion of the upper end of the tendon was cut away and the tendon was fastened to the short head by splitting and suture. Nine months later the result was perfect (Keen, in "Annals of Surgery," May,

Fig. 345.—Author's case of rupture of the long head of the biceps.

1905). *Rupture of the plantaris* is treated at first by rest in a posterior splint and compression and later by massage and the use of an elastic bandage. The patient is allowed to walk with a cane in one week, but does not raise the heel for several weeks.

Hernia of Muscles.—When a tear takes place in a muscular sheath, a portion of the muscle protrudes. The **treatment** is incision and suturing of the sheath.

Fig. 346.—Author's case of rupture of the long head of the biceps.

Contractions of muscles may result from injury, from joint-disease, from malposition of parts (as in old dislocation or torticollis), or from diseases of the nervous system. The **treatment** in some cases is sudden extension, in other cases gradual extension, tenotomy, or myotomy. Macewen recommends the making of a number of V-shaped incisions in the muscle. In some cases of spasmodic contraction nerve-stretching is of value.

Dislocations of Muscles and Tendons.—The long head of the biceps is oftenest displaced. The flexor carpi ulnaris, the peroneus brevis, the peroneus longus, the tibialis posticus, the sartorius, the plantaris, the quadriceps extensor femoris, and the extensors back of the wrist may be dislocated. What is known as dislocation of the latissimus dorsi, a condition in which that muscle no longer lies upon the angle of the scapula, is not a dislocation, but a paralysis. Most of these accidents are associated with chronic joint-disease or with fracture, but displacement may exist as a solitary injury. *Dislocation of the long head of the biceps* may occur tolerably early in the progress of rheumatoid arthritis of the shoulder-joint, and the displaced tendon may be absorbed.

Symptoms.—After dislocation of a tendon the muscle of the tendon can still contract, but it acts at a disadvantage; thus the corresponding joint exhibits partial loss of function. The displaced tendon can be felt, and a hollow exists where it normally resides.

When the muscle contracts, the tendon is felt to slip from its groove. When the tendon of the biceps is dislocated, the head of the bone passes forward (so-called *subluxation of the humerus*).

Treatment.—In tendon-dislocation reduction is easy, but the displacement is apt to recur because of laceration of the sheath. The treatment usually advised is to effect reduction by relaxation of the limb and manipulation of the tendon, to place the part upon a splint so that the muscle belonging to the tendon will be relaxed, and to apply pressure over the point of injury. This treatment generally fails, and if the tendon does not become firmly anchored in its proper situation in four weeks, we should operate. In some tendons it is enough to incise, freshen the edges of the torn sheath, and sew up with kangaroo-tendon or chromicized catgut. In a tendon lying in a long groove make a halter for the tendon by incising the periosteum and suturing it over the tendon.* Passive movements are begun at the end of the first week. Even if the tendon will not remain reduced, a useful joint will be obtained. Wood, of New York, advised in obstinate cases tenotomy and immobilization.

Wounds of Tendons.—Subcutaneous wounds of tendons are usually inflicted by the surgeon, and they heal well. Open wounds require rigid antisepsis and suturing of the tendon. In wounds of the wrist especially always suture the tendons (Fig. 92), and be sure to bring the proper ends into apposition.

Rupture of Tendons.—A violent muscular effort may rupture a tendon, and as the accident occurs, a snap may often be heard. The **symptoms** are sudden pain and loss of power, fullness of the associated muscle from retraction, and absolute inability to bring the tendon into action. A gap may often be felt in the tendon.

Treatment.—The best procedure in treating rupture of a tendon is exposure by incision and the introduction of sutures. Some surgeons relax the parts and apply splints.

Thecitis, or **tenosynovitis,** is inflammation of the sheath of a tendon.

Acute thecitis may arise from a contusion, from a wound, from repeated overaction in working or while engaged in some sport, from rheumatism

*Walsham's case of dislocation of the peroneus longus, Brit. Med. Jour., Nov. 2, 1895.

from gonorrhea, from influenza, from the continued fevers, or from syphilis. In early syphilis certain tendon-sheaths may rapidly develop effusion because of hyperemia of the sheaths (Taylor).

Symptoms.—In *non-suppurative* cases of thecitis the symptoms are pain, swelling, tenderness, and moist crepitus along the tendon-sheath, due to inflammatory roughening. The crepitus disappears as the swelling increases, but it reappears as the swelling diminishes. In *suppurative* cases the symptoms are great swelling, pulsatile pain, dusky discoloration, inflammation spreading up the tendon-sheaths, and often the constitutional symptoms of sepsis.

Treatment.—In treating non-suppurative thecitis, employ splints and apply locally iodin, blue ointment, or ichthyol, and administer suitable remedies to combat any causative constitutional disease. In the suppurative form make free incisions, irrigate, drain, and dress with hot antiseptic fomentations. (See Felon, page 647.)

Palmar Abscess.—We mean by this term an abscess beneath the palmar fascia and not a superficial collection of pus. Palmar abscess may arise after wounds, abrasions, burns, or inflammations of the skin of the

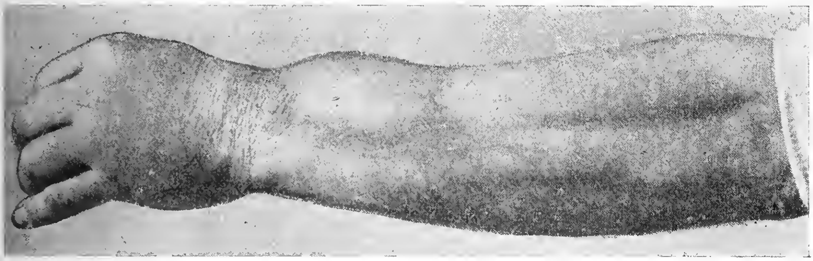


Fig. 347.—Tuberculous thecitis (compound ganglion).

palm. A thecal abscess in a flexor tendon of a finger travels rapidly upward and may produce a palmar abscess. A thecal abscess of either the index, ring, or middle finger is usually arrested at the lower end of the palm, but suppurative thecitis of the thumb or the little finger conducts pus along the tendon sheath and up the arm (Fig. 348). If the theca ruptures, pus is diffused over the palm. It produces great swelling of the hand and fingers, the dorsum being swollen as well as the palm. The fingers become flexed and rigid. Violent pulsatile pain and decided constitutional disturbance exist. Discoloration is late in appearing. Adjacent lymph-glands enlarge. Palmar abscess is a most serious affection. The pus may dissect up all the structures of the palm, may pass between the bones and reach the dorsum, or may pass beneath the anterior annular ligament into the connective-tissue planes of the forearm. In some cases it leaves a clawed, stiff, and useless hand.

Treatment.—A palmar abscess demands radical treatment at the earliest possible moment; delay will be responsible for stiff and contracted fingers and hyperesthetic skin, resulting in a damaged and perhaps a useless hand. The patient should be placed under the influence of ether. The incision is made

in the line of the metacarpal bone and, if possible, below the palmar arches. A line transverse with the web of the thumb is below the palmar arches. In an incision above this line, try not to cut either arch; but if one be cut, at once take means to arrest the hemorrhage (page 386). In a severe case it may be necessary to make several palmar incisions, to open the tendon-sheaths on the flexor surface of the forearm above the wrist, and to make counter-openings in the back of the hand, and it is sometimes necessary to introduce tubes, and drain through and through the hand. After operation apply hot antiseptic fomentations and put the part upon a splint. When granulations begin to form, dry dressings are substituted for the hot moist dressing. It may be necessary to give morphin for pain, and stimulants may be needed. There is great danger of stiffness of the fingers occurring, the tendons becoming adherent to their sheaths. Hence passive movements are inaugurated as soon as granulations begin to form.

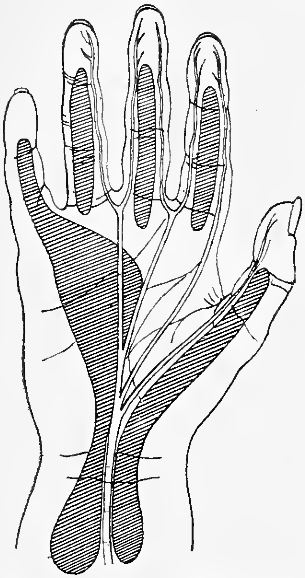


Fig. 348.—Diagram of tendon-sheaths of the hand (Tillaux).

Chronic thecitis may follow acute thecitis, but may be due to injury, to rheumatism, to gummatous infiltration, to rheumatoid arthritis, or to tuberculous inflammation of a tendon-sheath. Chronic thecitis is commonest in the tendons of the fingers, the ankles, and the knees; it may spread to a joint or it may arise from a tuberculous joint. This condition causes very little pain. In ordinary non-tuberculous thecitis the part is weak, tender, painful, and stiff, crepitates on motion, and is swollen. In *tuberculous thecitis* there is at first distention of the tendon-sheath with serum. The serum contains *rice*, *riziform*, or *melon-seed* bodies, and the wall of the tendon-sheath is here and there thickened and caseating. Later in the case the interior of the tendon-sheath becomes lined with tuberculous granulations and a tuberculous abscess may form. Rice bodies are sometimes fibrinous masses, are sometimes pieces of separated and dead recently formed fibrous tissue, and are sometimes masses of proliferating cells. In these tuberculous cases the swelling is firm or doughy when due to granulation tissue, but is fluctuating when due to fluid. Grating is marked. Tubercle bacilli are present in the fluid or in the granulation tissue. Tuberculous thecitis is most common about the wrist, constituting the so-called *compound ganglion* (Fig. 347).

Treatment.—*Tuberculous cases* are treated as follows: If there is a fluid effusion and no rice bodies, make a small incision, wash out with salt solution, introduce some iodoform emulsion, and close the wound. In cases in which there are rice bodies, open the sheath, evacuate the contents, scrape the walls thoroughly, inject with iodoform emulsion, and close the wound. (If the annular ligament requires division, stitch it—Fig. 358.) In cases with exten-

sive thickening apply an Esmarch bandage, make a large incision, and remove all infected tissue from the sheath, around the sheath, and from the tendon. In tuberculous thecitis Bier's method (page 228) may be of service and so may the x-rays. In an *ordinary traumatic thecitis* use for the first few days rest associated with applications of ichthyol. Later employ hot and cold douches, massage and passive movements, strapping of the part, inunctions of ichthyol, and the hot-air bath. If effusion is persistent or rice bodies exist, make an incision and scrape the interior of the tendon-sheath. In rheumatic cases give antirheumatic remedies and employ the hot-air bath. In syphilitic cases administer mercury and iodid of potassium.

Ganglia.—In connection with tendon-sheaths simple ganglia may develop. They are small, tense, round swellings, which are firm, grow progressively though slowly, are painless when uninflamed, and contain a fluid of the appearance and consistence of glycerin-jelly (Bowlby). Ganglia are commonest upon the dorsum of the wrist, and they occur especially in those who constantly use the wrist-muscles. Paget states that a *simple* ganglion is due to cystic degeneration of a synovial fringe inside a tendon-sheath, and that the fluid of the ganglion does not communicate with the fluid of the tendon-sheath. Other pathologists believe a simple ganglion to be a hernia of synovial membrane through a rent in a tendon-sheath, all communication between the herniated part and the tendon-sheath being soon obliterated. *Compound* ganglion is an old name for tuberculous thecitis.

Treatment.—A ganglion is treated by aseptic puncture with a tenotome, evacuation, scarification of the walls, antiseptic dressing, and pressure. An old-time method of treatment was subcutaneous rupture brought about by striking with a heavy book. Duplay treats a ganglion by injecting a few drops of iodin through a hypodermatic needle. The cyst is not evacuated before injection. The parts are dressed antiseptically, and cure is obtained in one week. Recurrent ganglia, very large ganglia, and ganglia with very thick contents should be dissected out.

Felon, or **whitlow,** is a violent, rapidly spreading pyogenic inflammation of a finger or a toe which resembles cellulitis, and which is sometimes followed by gangrene of the soft parts or by necrosis of bone (Fig. 349). As a rule, an injury precedes the whitlow—an abrasion of the surface which admits pus-organisms or a contusion which creates a point of least resistance. The commonest seat of a felon is the last digit of a finger or the thumb. An abrasion of the surface at this point absorbs pus-organisms and the superficial lymphatics carry the bacteria directly inward, the micro-organisms lodging, it may be, in the skin, in the subcutaneous tissues, in the tendon-sheath, or beneath the periosteum. The perpendicular direction of the fibers of the subcutaneous tissue favors this passage inward.

Felons are very rare in infants, but may occur in children. Women are more liable to them than are men. The fingers are much more prone to infection than are the toes, because they are more exposed to injury. Several fingers may be attacked at once or successively in persons of dilapidated constitution. Whitlow is most apt to occur and is most severe in persons broken down by disease, alcoholism, overwork, or worry. In certain cases of neuritis painless suppuration may arise. In syringomyelia *painless felons* are common, and they are apt to be associated with necrosis of bone. Pain-

less and destructive whitlows constitute a characteristic part of *Morvan's disease.*

There are two forms of felons, the *superficial* and the *deep.*

Superficial Felons.—One form of superficial felon is between the cuticle and the true skin and is rarely followed by involvement of deeper parts. The infection is in the skin. The point of infection becomes dark red, swollen, painful, and tender. The epidermis is lifted up into a pustule by the seropus which forms, and a considerable area may be attacked before the spread of the process is arrested. The commonest form of superficial felon is subcutaneous suppuration, the pus collecting in the fibro-fatty pad at the palmar surface of the last digit (G. B. Mower White, in "Brit. Med. Jour.," Feb. 24, 1906). This form often spreads deeply. If the subcutaneous tissues only are involved, the symptoms are those of an ordinary cellulitis. There is severe pain, increased by motion, pressure, and a dependent position. Swelling and discoloration are early and marked. Pus forms within forty-eight hours. *Paronychia,* or "*ring around,*" is a cellulitis starting at the end or side of the digit, and involving the parts around and below the nail. The pus-organisms obtain entrance by means of an abrasion, a puncture, or an ulcerated "step-mother." In paronychia pain is throbbing and violent; is increased by motion, pressure, or a dependent position; the skin is dusky red, but the swelling is slight. In about forty-eight hours pus forms in the superficial parts, the epidermis being lifted into pustules or blebs, and pus may also form under the nail. A portion of the nail or the entire nail may be lost.

Fig. 349.—Deep felon, with sloughing of soft parts and necrosis of bone.

If the tendon-sheath becomes involved as well as the subcutaneous tissue, the symptoms are those of suppurative thecitis, with more marked discoloration of the skin.

Deep Felons (Fig. 349).—There are two forms of deep felon. One is a thecal abscess involving the flexor tendon-sheath, arising secondarily to subcutaneous suppuration and spreading widely. In suppurative thecitis of the three middle fingers the process seldom reaches the palm; in suppurative thecitis of the theca of the thumb or little finger the pus may pass above the wrist and a true palmar abscess may form (Fig. 348). Another form is suppuration beneath the periosteum. This form is the so-called *bone felon.* It is occasionally primary, but more often arises secondarily to suppurative thecitis or to subcutaneous suppuration. In some cases a deep felon involves most of the struc-

tures of the finger (periosteum, bone, tendon, tendon-sheath, and cellular tissue), and may destroy the digit or the finger. The bacteria causative of a deep felon are lodged in the deeper parts. The pain is agonizing, entirely preventing sleep, pulsatile in character, associated with excruciating tenderness, greatly aggravated by motion or a dependent position, and often extending up the hand and forearm. The skin is dusky red and edematous, and the part is enormously swollen. Pus form quickly; diffuse cellulitis may arise; sloughing of the tendon and subcutaneous tissue may take place; necrosis of one or more bones may ensue, and in some cases gangrene of the finger follows.

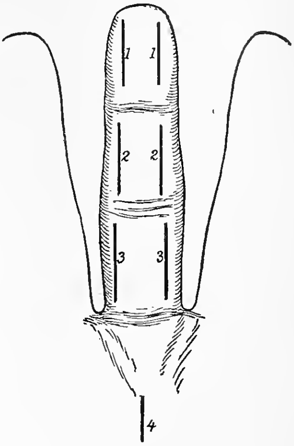


Fig. 350.—1, 2, and 3, Incisions for felon of finger and for ordinary suppuration; 4, palmar incision.

In deep whitlow lymphangitis of the forearm and arm is not unusual, adenitis of the axillary glands is common, and almost always there is fever. In superficial felon constitutional symptoms are slight or absent, and lymphangitis and adenitis arise in a minority of cases.

Treatment.—In a subcuticular felon, after cleansing, soften the parts well in an antiseptic fluid and then pare off the cuticle with a very sharp knife. This plan of White's is an excellent one; it gives vent to pus and prevents the inoculation of the deeper tissues which may follow incision. In subcutaneous suppuration incise the abscess, but be careful not to open the tendon-sheath or periosteum, as this would diffuse infection (White, in "Brit. Med. Jour.," Feb. 24, 1906). In neither of the above instances is it necessary to give an anesthetic. After operating the parts must be irrigated, dressed with hot antiseptic fomentations, and the hand must be placed upon a splint. In a deep felon I am convinced that we should operate immediately. Allay tension and prevent pus-formation by early incision. Do not waste time with poultices; to wait means agonizing pain, sleepless nights, constitutional involvement, and, perhaps, sloughing of tendons or death of bone. Incision and drainage constitute *the* treatment, but incision conducted in a particular manner. I have only lately learned how to treat a deep felon. I formerly treated all cases by incisions down to the bone alongside of the tendon (Fig. 350) and was frequently disappointed by a spread of the suppuration in spite of incisions, by necrosis of bone, or by extensive sloughing of tendons. A few months ago I obtained new light upon this subject from an article on "Whitlow," by G. B. Mower White ("Brit. Med. Jour.," Feb. 24, 1906). I immediately put in practice the common-sense suggestions in this valuable article and have seen a surprising improvement in results. The chief points in White's plan of treatment are as follows: To plunge a knife through an area of infection into a tendon-sheath if that sheath is not infected will lead to infection, and the way to be sure whether it is or is not infected is to look through a carefully made incision and see. After careful sterilization, anesthetize, drain the extremity of blood by elevation, and apply an Esmarch band to the arm. This enables us to see what

we are doing. Make an incision by the side of the tendon-sheath (Fig. 350), slowly and carefully, and on reaching it see if it is distended. If in doubt, insert a hypodermatic needle and withdraw fluid. If we get turbid serum, the theca is infected. If the theca is not infected, do not open it but incise the subperiosteal area of suppuration if it exists. If the theca is infected, remember that this infection has surely ascended more or less, and we must not only open at the lower point, but must also incise at the upper point. Do not incise the theca over the length of the tendon, as sloughing will follow. If one of the three middle fingers is involved, incise the distal end of the theca and also the proximal end over the head of a metacarpal bone in the mid-line, wash from opening to opening, and drain. If the theca of the thumb or little finger is involved, open distally and then proximally above the wrist. To reach the proximal end of the theca of the thumb cut at the radial side of the tendon the flexor carpi radialis. Also open the palmar sac of the flexor longus pollicis, making the cut along the inner border of the outer head of the flexor brevis pollicis.

To reach the proximal end of the theca of the little finger begin an incision at the upper margin of the annular ligament and carry it up along the inner border of the flexor sublimis. Retract the tendons and pus will usually be found between the tendons of the superficial and deep flexor. Look beneath the profundus tendons for the bursa and open it. Then open the palm by an incision in the line of the axis of the ring-finger. Thus three openings are made in either case, and the theca can be thoroughly washed and drained. If either the thumb or little finger bursa is found infected, the other must be exposed and examined, as they usually communicate at their proximal ends or a communication may form as a result of suppuration. Rupture of either bursa may diffuse pus widely. White, in order to prevent secondary hemorrhage, ligates the radial artery in two places and removes $1\frac{1}{2}$ inches of it (if operating on the thumb bursa); and ligates the superficial arch and removes 1 inch of it (if operating on the palmar expansion of the little finger theca). These arterial ligations seem a serious and perhaps unnecessary addition to the operation and I have not *practised* them. After thorough irrigation apply antiseptic fomentations and splint the extremity. If the patient cannot sleep, give morphin. See that the bowels are moved once a day. Give quinin, iron, and milk-punch. As soon as granulations begin to form, use dry dressings and make passive motion daily. If bone undergoes necrosis, let it loosen and then remove it. Amputation is sometimes necessary.

Bursitis is inflammation of a bursa. *Acute bursitis* arises from strain or from traumatism. The symptoms of acute bursitis are pain, limited swelling, moist crepitus, fluctuation, and discoloration in the anatomical position of a bursa. In *chronic bursitis* there is intermittent pain, tenderness, and progressive, fluctuating swelling. *Bursitis* of the *retrocalcaneal bursa* (*Albert's disease*) is a painful affection which is often overlooked. It is rather common in storekeepers who rise often on the toes to reach shelves, in motormen who use a foot gong, in street-car conductors, and clerks who stand at desks. It may follow gonorrhea. Walking causes great pain in the heel. Raising up on the toes is exceedingly painful. It is usually associated with flat-foot. In these cases osteophytes often form within the bursa. There are numerous bursæ about the hip. Some anatomists count twenty-one.* The two most important bursæ and the ones usually affected

* Synnestvedt, of Sweden.

are the iliac and the deep bursa over the great trochanter.* Inflammation of the *iliac* or *ilio-psoas bursa* produces swelling below Poupart's ligament, which swelling is tense, but exhibits fluctuation on careful examination. Often the swelling attains large size. In some cases the sac can be emptied by pressure, the fluid passing into an adjacent bursa or into the joint. The swelling is beneath the femoral artery and consequently lifts that vessel (F. B. Lund, in "Boston Med. and Surg. Jour.," Sept. 25, 1902). The enlargement often presses on the anterior crural nerve and causes spasmodic pain throughout the nerve's trajectory. The limb, according to Zuelzer, is usually slightly flexed, abducted and rotated outward, and movement in an opposite direction causes pain. Inflammation of the bursæ about the hip may produce symptoms resembling those of incipient coxalgia, but in bursitis the symptoms do not remit, as in hip-disease. Ilio-psoas bursitis occasionally results from gonorrhea. The bursa is sometimes involved in joint-disease. In inflammation of the iliac bursa flexion is not so marked as in coxalgia, and the trochanter is never above Nélaton's line. In inflammation of the deep trochanteric bursa the position is the same as in iliac bursitis, and resembles that of coxalgia. In coxalgia, however, there is pain on pressure upon the front of the joint or directly on the trochanter or on tapping the sole of the foot. These manipulations do not cause pain in bursitis (Zuelzer). In inflammation of the *gluteal bursæ* there is moderate pain back of the thigh and knee, which disappears when the patient is at rest; there are a marked limp, limitation of motion, and an area of deep fluctuation in the buttock (Brackett).

It is difficult to differentiate between inflammation of a deep bursa and synovitis; indeed, in bursitis the joint is apt to be secondarily affected. This difficulty is especially vexatious in distinguishing between joint-injury and injury of the bursa beneath the deltoid. Suppuration may take place in a bursa. Direct force may rupture a bursa. The bursa beneath the deltoid is frequently ruptured. When this accident happens, there are pain, marked swelling, a large area of moist crepitus, and later extensive discoloration from blood. *Chronic* bursitis may follow acute bursitis, or the disease may be chronic from the start. It may be due to tuberculosis. Bursæ particularly apt to become tuberculous are those about the hip, the subdeltoid, the olecranon, the prepatellar, and the retrocalcaneal. In tuberculous bursitis during the first stage the bursa is distended with fluid, due to oversecretion, the walls are thickened here and there, and perhaps contain caseous foci and rice bodies are found in the bursal fluid. In a more advanced stage the bursal wall is lined with caseating granulation tissue and the bursa may become a tuberculous abscess, the walls may give way with diffusion of the process, or mixed infection with pyogenic organisms may occur. In some cases of tuberculous bursitis tending to cure the bursal walls become enormously thickened by fibrous tissue. The **symptom** of chronic bursitis is swelling with little or no pain unless acute inflammation arises. Chronic bursitis of the subhyoid bursa is known as *Boyer's cyst*.

Treatment.—Acute bursitis is treated by rest, pressure, and the application of iodin, blue ointment, or ichthyol. If the swelling persists, aspirate and apply pressure, or incise the sac and remove it partly or completely. If pus forms, incise, paint the interior of the sac with pure carbolic acid,

* Zuelzer, in Zeit. f. Chir., vol. l.

and pack with iodoform gauze. Chronic bursitis may be cured by the use of pressure and the application of blue ointment, and with treatment of

Fig. 351.—Housemaids' knee.

Fig. 352.—Bursitis of left olecranon bursa of three years' duration.

any causative diathesis, but most cases require incision and packing. A ruptured bursa is treated as an acute bursitis. In bursal tuberculosis the

best treatment is excision. If we are dealing with a very deep bursa, the proper treatment is incision, scraping with a sharp spoon, mopping with carbolic acid, and packing with iodoform gauze.

Housemaids' knee (Fig. 351) is thickening and enlargement of the prepatellar bursa, the result of intermittent pressure. In effusion into the knee-joint the fluid is behind the patella and the bone floats up; in housemaids' knee the fluid is above the bone and the osseous surface can be felt beneath it.

"Miners' elbow" (Fig. 352), which is a condition similar to housemaids' knee, affects the olecranon bursa.

"Weavers' bottom" is enlargement of the bursa over the tuberosity of the ischium. A bursa which is simply thickened and enlarged rarely gives rise to annoyance; but when it inflames, as it is apt to do, it causes the ordinary symptoms of bursitis.

Treatment of Special Forms.—Some few cases of housemaids' knee may be cured by rest and blistering, but in most cases it is necessary to incise and pack with iodoform gauze. In enlargement of the bursa beneath the ligamentum patellæ, if rest and blistering fail to cure, aspirate or incise. In enlargement of the bursa beneath the tendon of the semimembranosus and also in "weavers' bottom" and in "miners' elbow," incise and pack. In operating for ilio-psoas bursitis I follow Lund's advice and make a vertical incision below Poupart's ligament, and between the anterior crural nerve and the femoral artery. The fibers of the ilio-psoas muscle are separated and the bursa is opened and drained. Some few cases of retrocalcaneal bursitis recover after rest, but most of them require incision and drainage. If osteophytic formations exist, the bony stalactites must be removed by means of the rongeur. Flat-foot, if it exists, is treated by a support (page 663).

Fig. 353.—Enlargement of the deep infrapatellar bursa, chronic, and the result of traumatism.

Bunion.—A bunion is a bursa due to pressure, and it is most commonly situated above the metatarsophalangeal articulation of the great toe, but is occasionally seen over the joint of another toe. When the big toe is pushed toward the other toes by ill-fitting boots, a bunion forms. When a bunion is not inflamed, it may cause but little trouble; but when it inflames, the bursa enlarges and the parts become hot, tender, and exceedingly painful. Suppuration may occur and pus may invade the joint, and the bone not unusually becomes diseased.

Treatment.—In treating a bunion the patient must wear shoes that are not pointed, that have the inner border straight, and that have rounded toes (Jacobson). For a mild case a bunion-plaster gives comfort. Sayre

advises the use of a linen glove over the digits, the phalanges being drawn inward by a piece of elastic webbing, one end of which is fastened to the glove and the other end to a piece of strapping from the heel. A special apparatus may be worn (Fig. 354). In many cases osteotomy of the first phalanx or of the first metatarsal bone is required; in some cases excision of the joint is necessary; in others amputation must be performed. When the bursa is not inflamed, but only thickened, blisters should be employed over it, or there should be applied tincture of iodin, ichthyol, or mercurial ointment. When the bursa inflames, ichthyol ointment is applied, and intermittent heat by foot-baths gives relief. Suppuration demands immediate incision and antiseptic dressing. If an ulcerated bunion does not heal by antiseptic dressing, stimulate it with nitrate of silver and dress it with unguent. hydrarg. nitrat. (1 part to 7 of cosmolin). Jacobson recommends skin-grafting for some cases.

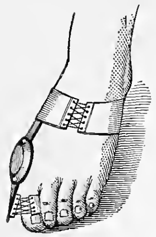


Fig. 354.—Bigg's apparatus for bunions.

Operations upon Muscles and Tendons.

Tenotomy is the cutting of a tendon. It may be *open* or *subcutaneous*, the open operation being preferred in dangerous regions.

Open Division of the Sternocleidomastoid Muscle for Wry-neck.—Subcutaneous tenotomy for wry-neck has been largely abandoned. It is not only more unsafe than the open operation, but it never completely divides all the contracted band.

The instruments required consist of a scalpel, dissecting forceps, hemostatic forceps, scissors, needles, ligatures, etc. The patient is placed recumbent, the chin being drawn more than is habitual toward the opposite side.

A transverse incision is made over the muscle about one-fourth of an inch above the clavicle. The superficial parts are divided, the muscle is exposed and sectioned, bleeding is arrested, and the skin is sutured. Avoid the anterior jugular vein, which is underneath the muscle, and also the external jugular, which is close to the outer edge of the muscle. Mikulicz advocates the removal of almost the entire muscle, leaving, however, the upper and posterior portion where the spinal accessory nerve passes. After operation for wry-neck support the head with sand-bags or a plaster-of-Paris dressing until healing occurs, and then inaugurate motions, active and passive.

Subcutaneous Tenotomy of the Tendo Achillis.—This operation is performed for club-foot, in which the heel is raised. The tendon is cut about one inch above its point of insertion. The instrument used for the first puncture is a sharp tenotome. The patient lies upon his back, "with his body rolled a little toward the affected side" (Treves), the foot being placed upon its outer side on a sand-pillow. The surgeon stands to the outer side. The tendon is rendered moderately rigid, and a sharp tenotome, with its blade turned upward, is inserted along the anterior border of the tendon until the surgeon's finger feels the knife approaching the outer side. The sharp-pointed instrument is withdrawn and a blunt-pointed tenotome is inserted in its place. The tendon is drawn into rigidity, and the surgeon

turns the blade of his knife toward the tendon, places his finger over the skin, and saws toward his finger. The tendon gives way with a snap. Treves states that a beginner is apt not to push the knife far enough toward the outside, or he may in the first puncture push the knife through the tendon; in either case the tendon is not completely cut. The little wound, which is covered with a bit of gauze, will be entirely closed in forty-eight hours. In club-foot cases after tenotomy some surgeons at once correct the deformity and immobilize the limb in plaster; some partially correct the deformity and apply plaster for one week, at which time they remove the plaster, correct the deformity further, reapply the plaster, and so on; other surgeons do not attempt correction of the deformity until the cut tendon has begun to unite, when they gradually stretch the new material.

Subcutaneous Tenotomy of the Tendon of the Tibialis Anticus Muscle.—The tendon is divided about one and a half inches above its point of insertion. It can be made tense by extending and abducting the foot. The sharp-pointed tenotome is entered upon the outside of the tendon, and is passed well around it. The blunt-pointed tenotome is used to cut the tense tendon.

Subcutaneous Tenotomy of the Tendons of the Peroneus Longus and Brevis Muscles.—These two tendons are cut together back of the external malleolus, and one and a half inches above the tip of the malleolus, so as to avoid the synovial sheath (Treves). The patient lies upon the sound side, the outer aspect of the deformed foot being upward and the inner aspect of the ankle of the deformed side resting upon a sand-pillow. A sharp tenotome is introduced close to the fibula, and is carried around the loose tendons. A blunt-pointed tenotome is now introduced, its edge is turned toward the tendons, and these structures are cut as they are made tense.

Subcutaneous Tenotomy of the Tendon of the Tibialis Posticus Muscle.—This tendon is sectioned above the point where its synovial sheath begins; that is, above the internal annular ligament (Treves). The tendon is made tense and the pointed knife is entered above the base of the inner malleolus. The knife is entered just back of the inner edge of the tibia, and is carried around the muscle and is kept close to the bone. The tendon is sectioned with a blunt knife.

Subcutaneous Fasciotomy of the Plantar Fascia.—The contracted bands are discovered by motions which render them tense, and they are divided just in front of the attachments to the os calcis. The sharp knife passes between the skin and fascia at the inner side of the sole of the foot. The fascia is cut from without inward by the blunt-pointed tenotome. It is usually necessary to section the fascia at more than one point.

Tendon-suture and Tendon-lengthening.—The instruments required in these operations are an Esmarch apparatus; curved needles, and needle-holder; chromicized gut, kangaroo-tendon, or silk for an ordinary case, silver wire for a suppurating wound. In performing tendon-suture make the part aseptic and bloodless. It is wise to apply a rubber bandage on the proximal side, the bandage being applied centrifugally, forcing the proximal end of the tendon into view (Haegler). If searching for the proximal end of a flexor of the finger, flex the injured finger, and hyperextend the adjoining fingers (Filiget). If this expedient fails, enlarge the incision, or, what is

better, make a large flap in the skin. After finding the ends approximate them, being sure the proper ends are brought into contact; stitch them together with a continuous suture or with one of the sutures shown in Fig. 355, 1, 2, and 3. In a suppurating wound suture by silver wire should be tried, though it usually fails. After suturing, remove the Esmarch apparatus, arrest bleeding, close the wound and dress it antiseptically, relax the parts, and place the limb on a splint. If, after suturing, there is much tension, stitch the cut tendon above the sutures to an adjacent tendon, and apply a splint, the finger which was injured being flexed, the others being extended.

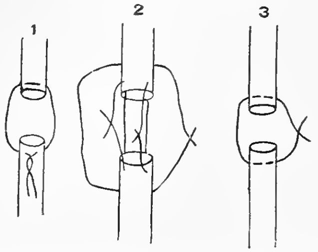


Fig. 355.—Tendon-sutures: 1, Of Le Fort; 2, of Le Dentu; 3, of Lejars.

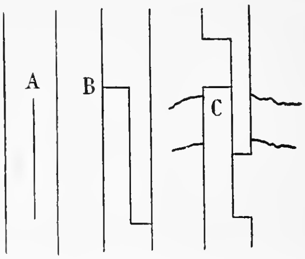


Fig. 356.—Anderson's method of tendon-lengthening.

If only the distal end of the tendon can be found, graft it upon the nearest tendon with a like anatomical course and function. When a tendon has been sutured, begin gentle massage in two weeks. Positive passive motion is begun in three or four weeks. In old injuries, when the ends cannot be brought into apposition, lengthen one end or both ends, either by the method of Anderson (Fig. 356) or by the method of Czerny (Fig. 357). Dr. J. Neely Rhoads ("Med. News," Nov. 28, 1891) suggested that slight lengthening could be accomplished by "cutting half through the tendon at different levels and from opposite sides, leaving some longitudinal fibers to slip on

Fig. 357.—Czerny's method of tendon-lengthening.

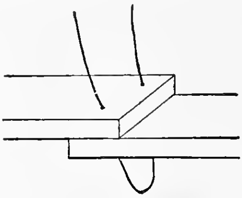


Fig. 358.—Method of suturing the annular ligament of the wrist.

each other, thus gaining slight elongation" (H. Augustus Wilson, in "International Clinics," vol. i, 4th series). Poncet makes several zigzag incisions on each side of the tendon, and when the tendon is pulled upon it elongates decidedly. Hibbs's method is shown in Fig. 359. One of these methods of lengthening may be used if there is deformity from tendon-contraction. If the tendon cannot be lengthened sufficiently, make a bridge of catgut from one end of it to the other, or graft in another tendon from one of the lower animals, or graft the distal end to a tendon of like function (*tendon-grafting*).

The annular ligament is sutured as shown in Fig. 358.

Tendon-transplantation.—This operation is usually said to have been devised by Nicoladoni in 1882; as a matter of fact, Duplay did the operation in 1876, endeavoring to secure function in an arm rendered powerless by an injury (Elting).

The first American surgeon to do the operation was Parrish, of New York, who in 1892 transplanted tendons in a case of club-foot. In some cases in which a muscle has been paralyzed surgeons have divided the tendon of the paralyzed muscle and have united its distal end with the tendon of a normal muscle, the normal tendon being split to receive it. It has also been stated that when a muscle or the tendon of a muscle is sutured to a paralyzed antagonistic muscle, the transplanted structure will actually execute the functions of the paralyzed muscle. For instance, a flexor, when so transplanted, may become an extensor and act under the mental impulse of extension; a pronator may become a supinator (H. A. Wilson in "American Med.," April 8, 1905). These principles have been utilized when some or many of the muscles of a limb have been paralyzed, the tendon of an unparalyzed muscle or the tendons of an unparalyzed group of muscles being fastened to the tendons of the paralyzed muscle. It has been shown that the success of this procedure depends upon the accuracy of diagnosis, the division of secondary contractures, the correction of existing deformities, and careful after-treatment. (See the article

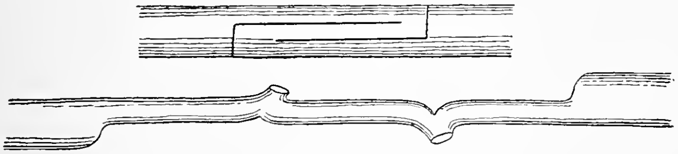


Fig. 359.—Hibbs's method of tendon-lengthening.

by Dr. J. Hilton Waterman, in "Med. News," July 12, 1902.) In a paralysis of the lower extremity, as Goldthwait points out, the sartorius usually retains power, and it may be advisable in such a case to divide the sartorius and suture its upper end to the quadriceps above the patella. A strip of the tendo Achillis may be grafted upon the peronei in certain cases. An artificial tendon may be made of silk, the silk being passed from the sound to the paralyzed tendon (Lange); the silk eventually becomes surrounded by fibrous tissue. Strands of silkworm gut may be used for the same purpose (Kummell). The operation of tendon-transplantation is occasionally of distinct benefit, but I agree with Ridlon, and am sanguine of results. Ridlon wisely reminds us that in such cases much good may perhaps result from the proper use of braces, tenotomy, and hand stretching, followed by prolonged retention in plaster, the patient using his limb actively (Practical Medicine Series. Volume on Orthopedic Surgery, edited by John Ridlon with the collaboration of Gilbert L. Bailey).

Ridlon points out that most brace treatment is not curative because it only aims to prevent deformity developing, and tenotomy and stretching fails because it only seeks to remove existing deformity. The object should be some restoration of function. This is often obtained by following Thomas's direction and "posturing" the limb so as to permit structural shortening of the paralyzed muscles and then fixing there for months.

XXI. ORTHOPEDIC SURGERY.

This branch of surgery formerly dealt only with the treatment of deformities by means of mechanical appliances, but of recent years its domain has been enlarged to include the treatment, surgical and mechanical, of deformities, contractures, and many joint-diseases.

Torticollis (wry-neck) is a condition in which contraction of certain of the neck-muscles causes an alteration in the position of the head. The disease is one-sided; the sternocleidomastoid is the muscle chiefly involved, though the trapezius, the splenius, and other muscles sometimes suffer. Acute torticollis, which is rare, is a temporary condition, and results from cold or from injury (see Myalgia). Chronic torticollis may be congenital, may be due to nerve-irritation, to an assumed attitude because of eye-defect, to inflammation of the glands or to disease of the vertebræ, and it may be intermittent, but is usually persistent. The muscle stands out in bold outline, the head is turned to the opposite side, the ear of the disordered side is turned toward the shoulder, the chin is thrown forward, and spinal curvature may arise. The corresponding side of the face atrophies. There is no pain. In many cases the head may be restored to its normal position by passive movement or by voluntary effort, but it at once returns to its habitual position. Mikulicz asserts that torticollis is a chronic fibrous myositis, due often to compression during labor. He further says that the lesion known as hematoma of the sternomastoid, which occasionally follows labor, is not hematoma, but thickening due to myositis. In spasmodic wry-neck the muscle is thrown repeatedly into clonic contractions. In congenital torticollis the muscle and the cervical fascia are shortened, and the muscle does not relax under the influence of an anesthetic. In torticollis due to rheumatism and reflex causes the tonically contracted muscle relaxes when the patient is anesthetized.

Symptoms.—*Congenital* wry-neck is due to central nervous disease, to spinal deformity, or to injury during birth, and in this form the sternomastoid is shortened, hardened, and atrophied. It may not be noticed for some years because of the short neck of infancy. It is associated with asymmetrical development of the face, and is almost invariably upon the right side. *Spasmodic* wry-neck may present tonic spasm only, intermittent spasm alone, or both may appear alternately. It sometimes arises in those whose occupation demands frequent rotation of the head, but more often no such cause can be discovered. It is probably a disease of the cortical area which presides over rotation of the head. (See article by C. A. Hamann, in "Buffalo Med. Jour.," Dec., 1901.) It is a disease especially of adults; in women it is often linked with hysteria. The exciting cause may be a cold, a blow, or a mental storm; the predisposing cause is the neurotic temperament. It may be due to enlarged glands, to carious teeth, or to eye-strain. In some rare cases bilateral spasm occurs, the head being pulled backward and the face being turned upward. Clonic spasms may come on unannounced, or they may be preceded by pain and stiffness; the head can be held still for a moment only; there is sometimes pain, always fatigue, but during sleep the contractions cease. The attack will probably pass away, but will almost certainly recur.

Treatment.—Congenital wry-neck is treated by myotenotomy (through an open wound) and the use of proper braces and supports. The old subcutaneous myotenotomy should be abandoned, as aseptic incision enables the surgeon to see and to feel all the contracted bands of fascia, muscle, and tendon, and to avoid vital structures (page 551). In spasmodic wry-neck treat the neurotic temperament and remove any obvious irritation (eye-strain, carious teeth, enlarged glands). Drugs are practically useless. The rest cure is sometimes beneficial. Tenotomy is not to be employed. In persistent cases stretch or divide and exsect a part of the spinal accessory nerve (Keen). To reach this nerve, make an incision along the posterior edge of the sternocleidomastoid muscle, find the nerve as it emerges from under the middle of the muscle, about one and a half inches below the tip of the mastoid process, retract the muscle at this point, and remove at least one inch of nerve. Neurectomy of the spinal accessory nerve paralyzes the sternocleidomastoid muscle, in spite of the fact that that muscle has also a nerve-supply from the cervical nerves. The paralysis is followed by atrophy, and if the spasm affected the sternomastoid muscle only, the operation will cure the case. Unfortunately, other muscles are usually involved, and cure will only be obtained by performing neurectomy on the nerves which innervate the affected muscles. For the treatment of rheumatic wry-neck see Myalgia (page 637).

Dupuytren's contraction is a contraction of the palmar fascia, of its digital prolongations, and of the fibers joining the fascia and skin. Fixed contraction of one or more fingers occurs. The ring-finger and the little finger most often suffer, but any finger or the thumb may be involved. The condition may be symmetrical. The disease arises oftenest in men beyond middle age, but is sometimes met with in youths. The **cause** of this disease is unknown; some refer it to gout or rheumatism; others to traumatism, reflex irritation, or neuritis. If due to traumatism, the right hand should suffer most frequently; but it occurs in the left hand nearly as often as in the right (P. Jansen, in "Arch. f. klin. Chir.," Bd. lxvii, H. 4). Jansen examined specimens from seven cases and found connective-tissue hypertrophy and circulatory disturbance, the contraction being a result of the above-named processes.

Symptoms.—Dupuytren's contraction is indicated by a small hard lump or crease which appears over the palmar surface of the metacarpophalangeal joint. This nodule grows and the corresponding finger is gradually pulled down. In some cases the tip of the finger is forced against the palm. The skin becomes dimpled or puckered.

Treatment.—In treating Dupuytren's contraction subcutaneous multiple incisions may be made, the tense fascia and the fasciocutaneous fibers being cut. The finger is straightened and is placed upon a straight splint, which is worn continuously for a week or ten days and is worn at night for at least a month. A more satisfactory operation is that of Keen. Keen divides the skin by a V-shaped cut, the base of the V being downward, lifts up the flap, and dissects out the contracted tissue. A cure is most certain to be obtained by Lexer's radical operation. This surgeon excises the entire aponeurosis and considerable portions of the palmar skin adherent to the aponeurosis. In order to cover this wound it may be necessary to slide a pedunculated flap into the raw surface.

Syndactylism (webbed fingers) is always congenital, and may persist through several generations. Simple incision of the web is useless; the operation to be performed is that of Agnew or of Diday (Figs. 360, 361).

In Agnew's operation a flap of skin from the dorsum is inserted between the fingers and sutured in place.

In Diday's operation a flap is taken from the dorsal surface and another flap is raised from the palmar surface, and each flap is sutured to the finger from which it springs.

Polydactylism (supernumerary digits) is always congenital, is often hereditary, and is usually symmetrical. There may be an incomplete digit, or there may be an entire and well-developed finger or toe with a metacarpal or metatarsal bone. The connection to the metacarpus or metatarsus may be by a fibrous pedicle only. If the digit is complete, with a metacarpal bone, no operation is required; if it is incomplete or is ill-developed, it should be removed.

Trigger-finger or Jerk-finger.—The patient can usually close the fingers, but on trying to open them one finger remains closed. It can be opened by grasping it with the other hand, but flies open with a snap like an opening knife (Abbe). In some cases two fingers are involved. In a

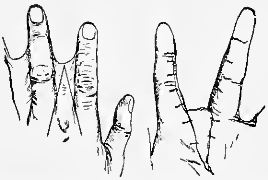


Fig. 360.—Agnew's operation for webbed fingers (Pye).

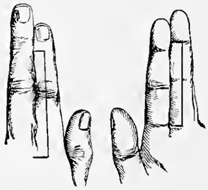


Fig. 361.—Diday's operation for webbed fingers (Pye).

reported case (Frederic Griffith, "Annals of Surgery") the ring and middle fingers of the left hand locked at the knuckle-joints on attempting flexion. The locking occurred when about one-third the amount of flexion necessary to grasp an object was achieved. By bending the fingers with the other hand unlocking was accomplished and flexion was finished voluntarily. In attempting extension blocking occurred at the same point and unlocking was accomplished in the same manner. In most cases, but not in all, there is pain when locking occurs. The condition is gradual in onset. Trigger-finger is often associated with rheumatism (in 52 cases out of 121, according to Necker). It is said by Tubby to be due to enlargement of the flexor tendon, or to contraction of the groove in the transverse ligament in the palm. It may be due to a ganglion, enchondroma, or tenosynovitis. Traumatism or irritation may produce it. The tendon-sheath may be thickened, or, according to Marcano, there may be a nodule on the tendon which rubs against the sesamoid bone (Griffith). It may result from occupation.

Treatment.—If a ganglion, a loose cartilage, or a sesamoid bone exists, treat by incision. If there is inflammation, use massage and counter-irritation. If there is no obvious cause, put a compress over the tunnel in the ligament and apply a splint.

Mallet=finger.—This is called also *drop-finger* and *rupture of the extensor tendon.* It is due to a blow in the direction of flexion when the finger is extended. It is supposed to be due partly to stretching and partly to rupture of the extensor tendon at the point at which it is the posterior ligament of the distal interphalangeal joint. Abbe has shown that baseball players are liable to a condition which is the reverse of this, in which the last phalanx is dislocated backward. Drop-finger is treated by incision and suture of the tendon to the periosteum.

Genu valgum (**knock=knee**) results from an unnatural growth of the internal condyle, causing the shaft of the femur to curve inward and the internal lateral ligament of the knee-joint to stretch, the knees coming close together and the feet being widely separated. This deformity is usually noted when the child begins to walk, but it may not appear until puberty or even long after. Knock-knee may arise from rickets, from an occupation demanding prolonged standing, or from flat-foot. It may occur in one knee or in both knees.

Fig. 362.—Club-hand.

Treatment.—Mild rachitic cases of knock-knee may remain in slight deformity, or may get well from improvement of the general health. In ordinary cases simply treat the rickety condition. The patient is forbidden to stand or to walk, and the limb, after being put as straight as can be, is fixed on an external splint and a pad is put over the inner condyle. Later in the case plaster-of-Paris is used. Some surgeons prefer to immobilize while the leg is flexed to a right angle with the thigh. In a severe case the surgeon can immobilize after forcibly straightening (causing an epiphyseal separation) or after the performance of osteotomy (page 611). Osteotomy is preferable to fracture by a mechanical appliance (osteoclasis).

Genu varum (**bow=legs**) is the opposite of knock-knee. Usually both legs are bowed *out*, the knees being widely separated, the tibiæ and femora, as a rule, being curved, and the feet being turned in. This disease in early life is due to rickets, the weight of the body producing the deformity. In older people incurable bow-legs may arise from arthritis deformans.

Treatment.—Some mild cases of genu varum recover as a result of improvement in the health. Ordinary cases are treated by braces, by plaster-of-Paris bandages, and by attention to the general health. When the bones have hardened in severe deformity, osteotomy is necessary.

Club-hand (Fig. 362).—A congenital deformity in which the hand deviates from the normal relation to the forearm. It is usually associated with other deformities. In some cases the radius and possibly some of the carpal bones are absent.

Treatment.—By massage and passive motion, by immobilization, by tenotomy or osteotomy.

Talipes (club-foot) is a permanent deviation of the foot into deformity. There are several forms. *Talipes equinus* (Fig. 363) is a confirmed extension; *talipes calcaneus* (Fig. 364) is a confirmed flexion; *talipes varus* is a confirmed adduction and inversion; and *talipes valgus* is a confirmed abduction and eversion. Two of these forms may be combined, as in talipes equino-varus (Fig. 365, talipes equino-valgus, talipes calcaneo-varus, and talipes calcaneo-valgus. The **causes** of talipes are congenital or acquired. The congenital form is due to persistence of the fetal form of the foot. Acquired cases may arise from infantile paralysis, from spastic contractions, from cicatrices, from traumatisms, from arrest of bony growth following upon the inflammation of bone, or from hysterical contractures.


Fig. 363.—Talipes equinus (Albert).

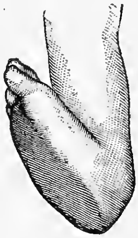


Fig. 364.—Talipes calcaneus (Albert).

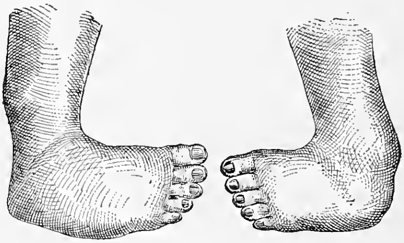


Fig. 365.—Double equino-varus ("American Text-book of Surgery").

Talipes equinus is rarely congenital. In this condition the patient walks upon the toes and cannot bring the heel to the ground.

Talipes Calcaneus.—The patient walks upon the heel and cannot bring the toes to the ground. The true form is seen in congenital cases, the flexors of the foot being shortened, and the tendo Achillis being lengthened.

Talipes varus is rarely met with without equinus. In this condition the patient walks on the outer edge of the foot.

Talipes valgus is met with in flat-foot. The patient walks on the inner edge of the foot.

Talipes equino-varus.—The heel is raised and the patient walks upon the outer edge of the foot. This is the usual congenital form.

Talipes equino-valgus is very rarely congenital. The heel is raised and the patient walks upon the inner side of the foot.

Talipes calcaneo-varus is a combination of calcaneus and varus.

Talipes calcaneo-valgus is a combination of calcaneus and valgus.

Treatment.—In congenital cases the condition is usually manifest on both sides, and is nearly always talipes equino-varus. Congenital club-foot should be treated in infancy, and when a restoration to position can be effected

by the hands of the surgeon, is treated by plaster-of-Paris bandages. If a child has begun to walk, it may still be possible to correct the deformity eventually by manipulations, by plaster-of-Paris bandages, or by club-foot shoes, but most cases require tenotomy of the tendo Achillis before the application of the shoe or the plaster. The club-foot shoe may do good service, but in many instances it is painful and is not so efficient as plaster-of-Paris. In severe cases, before applying the plaster, the patient is given ether; the surgeon cuts the tendons of the anterior and posterior tibial muscles, the plantar fascia, and the tendo Achillis, in the order named, and forcibly corrects the deformity. In old cases, with alteration in the shape of the bones, cuneiform osteotomy, or the removal of the cuboid or other tarsal bones, may be indicated. In these cases Phelps advises an open transverse division of all rigid plantar soft parts. Buchanan employs subcutaneous division of all resistant structures. Occasionally in relapsed and inveterate cases *astragalectomy* is performed. It is seldom practiced upon young children. (See page 631.) In some cases of talipes calcaneus shortening of the tendo Achillis is advised; but such an operation is only of temporary value, as stretching occurs after two years or more. In talipes due to infantile paralysis the operative treatment is the same, but we should not immobilize in plaster but rather in some apparatus which can easily be removed to permit the use of massage and electricity. In paralytic cases tendon-transplantation is occasionally employed. This consists in dividing the tendon of the paralyzed muscle and attaching its distal end to the adjacent tendon of a healthy muscle. (For full consideration see a work on orthopedic surgery.)

Fig. 366.—Print of a normal foot-sole (A) and of a flat foot-sole (B) (Albert).

Pes planus (flat-foot) is a condition in which there is loss of the arch of the foot, due to muscular paralysis or ligamentous weakness, to prolonged standing, or to trauma. Flat-foot is especially apt to occur in rickets. *Spurious flat-foot*, or *inflammatory flat-foot*, occurs in Pott's fracture and in inflammation of the ankle-joint or of the tendon of the peroneus longus muscle. *Paralytic flat-foot* is seen after infantile paralysis. *Static flat-foot* is due to disproportion between the body weight and the support of that weight. All children are born with pronated feet; the arch usually begins to form soon after birth, but in some individuals it never forms. Flat-foot, according to de Vlaccos, is thus produced: If we suppose a straight line prolonged downward from the center of the leg, most of the astragalus and os calcis will be external to it; hence the body weight presses on the inner side of the foot, and tends to flatten the arch and cause outward rotation, tendencies which are antagonized by the flexors of the toes and by the tibialis posticus muscle. The os calcis is pronated and is pushed to the side, the astragalus moves after the os calcis, and the ligaments are stretched ("Rev. de Chir.," Aug., 1901). Pes planus is productive of much pain upon standing or walking; in fact, the individual may be completely crippled. Pain is quickly relieved upon sitting down. Walking upon the toes is not painful. A marked flat-foot can at once be recognized by wetting the sole of the patient's foot with a colored fluid and causing him to step firmly upon a piece of paper (Fig.

366, A, B). Beginning flat-foot cannot be thus recognized and is frequently overlooked, the patient being treated for gout or rheumatism. Even a slight case can be detected by carefully observing the inner surface of the foot. When weight is placed upon it, it is seen to descend as the arch falls. A more accurate method is measurement, to find the middle of the foot. In flat-foot the extremity is lengthened. Golding-Bird points out that the middle of the normal foot is the point of articulation of the inner cuneiform and the metatarsal bone of the great toe. In flat-foot the greatest change is in the posterior half of this line. The extent to which the posterior measurement exceeds the anterior is the degree of flat-foot. The excess may reach three-fourths of an inch.

Treatment.—In *paralytic flat-foot*, which arises from infantile paralysis, employ exercise, electricity, and massage. In *static flat-foot* rest in bed is employed for two weeks, and then exercise is practised several hours a day to increase the arch. Rising upon the toes again and again is valuable. After exercise the patient rests for a time, sitting tailor-fashion with the legs crossed under him. Massage is valuable. A shoe should be made containing a piece of steel so arranged as to raise the arch of the foot. The patient's general health must also be attended to. In very severe cases, with fixation and bone-formation, operation may be required. Gleich shortens the foot and raises the arch by sawing through the os calcis and fastening the posterior part of this bone at a lower level. Trendelenburg advises supramalleolar osteotomy. This operation permits of adduction, and the adducted foot should be put up in an immovable dressing of plaster-of-Paris. Ogston resects the astragalo-scaphoid joint; Golding-Bird and Davy remove the scaphoid bone; Stokes removes a wedge-shaped piece from the head and neck of the astragalus.

Fig. 367.—*x*-ray of hammer-toe.

Pes cavus (hollow foot) is an increase in the arch of the foot, due, possibly, according to Golding-Bird, to paralysis of the peronei muscles. When the peronei muscles are paralyzed, the adductors act unopposed, and secondary contraction of the plantar fascia occurs. Certain it is that a contracted plantar fascia is the chief obstacle to correction. In many cases the cause is the wearing of shoes which are too short for the feet. The pressure made upon the toes causes spasm of the plantar flexors and this spasm permits the fascia to contract.

Treatment.—A shoe is worn containing a plate of steel in the sole, and pressure is applied over the instep. Tenotomy, division of the plantar fascia, or excision of bone may be required. In paralytic cases apply electricity and massage to the paralyzed muscles.

Hallus valgus, or **varus,** a displacement of the great toe outward or inward, may occur in the young, but it is most frequent in old persons, especially old women. It arises often from wearing pointed shoes, shoes that are too short, or high heels, but may be due to gout or to rheumatic gout.

In many cases an exostosis forms in the inner portion of the distal end of the metatarsal bone. In hallux valgus a *bunion* (bursa) is apt to form over the metatarsophalangeal joint and it may inflame or ulcerate.

Treatment.—An arrangement may be worn to straighten the toe and to protect the bunion (Fig. 354). The prominent and hypertrophied inner portion of the head of the metatarsal bone may be removed by means of a chisel, osteotomy may be performed upon the metatarsal bone, the joint may be excised, or amputation may be required. H. A. Wilson advocates lateral excision. By means of bone-forceps he cuts away that part of the distal extremity beyond the phalanx, and with a chisel removes the remaining sharp line edge. He places the phalanx in normal position and holds it so for two weeks ("Am. Jour. Orthopedic Surgery," Jan., 1906).

Hammer-toe (Figs. 367 and 368) is a condition in which there is flexion of one or more toes at the first interphalangeal joint. Shattuck shows that this condition is due to contraction of "the plantar fibers of the lateral ligaments of the joint."* This disease usually begins in youth and may be congenital. A bunion is apt to form, and the joint may become dislocated.

Treatment.—Terrier's plan of treatment consists in making a dorsal flap, removing a bursa if one is found, dividing the extensor tendon, opening the articulation, removing each articular surface with cutting forceps, suturing the soft parts, and applying a plantar splint for two weeks.† Some surgeons excise the joint. Probably amputation of the toe is the best treatment.

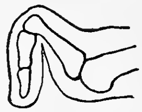


Fig. 368.—Hammer-toe.

Metatarsalgia (Morton's Disease).—This disease was first described by Dr. Thomas G. Morton, of Philadelphia, in 1876. It is a painful condition of the foot, due to jamming of a nerve between the heads of the fourth and fifth metatarsal bones. The head of the fifth metatarsal bone is, by lateral pressure, forced against and below the neck of the fourth metatarsal, and as a result the superficial branch of the external plantar nerve and its two digital branches are squeezed. It is usually associated with flat-foot. Pain is produced by walking, and the suffering may be so severe that the patient is obliged to sit down at once. When the shoe is removed and the foot is rested, the pain soon abates. The pain is felt on the outer and inner sides of the little toe, the outer side of the fourth toe, and about the head of the fifth and the neck of the fourth metatarsal bones. Pain can be developed by grasping the foot in the hand and squeezing it. If flat-foot exists, there is also pain due to this trouble.

Treatment.—Mild cases may be cured occasionally by wearing well-fitting shoes and employing massage. Some cases require a brace. Severe cases demand resection of the fourth metatarsophalangeal joint, or amputation of the fourth toe, and with it the head of the fourth metatarsal bone. Graham, of Washington, has cured cases by excising a portion of the superficial branch of the external plantar nerve.

Coxa vara is a disease characterized by bending of the neck of the femur, the hip-joint being perfectly healthy, and the condition, as a rule, being unilateral. This condition was described by Müller in 1889. Coxa vara begins, as a rule, between the thirteenth and twentieth years, and the com-

* American Text-Book of Surgery. † Rev. de Chir., July, 1895.

monly accepted view has been that the deformity is rachitic, but Kredel has reported two congenital cases.* Traumatic coxa vara may follow fracture of the neck of the femur in a child. The patient develops a limp, and grows tired after slight exertion, but there is no swelling nor tenderness, and little or no pain. Shortening after a time becomes apparent, and the trochanter can be detected above Nélaton's line. The extremity is adducted. The *x*-rays show the deformed bone.

Treatment.—As long as bending is progressing employ rest. When the bone hardens, it may be necessary to perform osteotomy below the trochanters.

Flail-joints.—After an attack of infantile paralysis involving the entire lower extremity of each side the limbs become limp and swing flail-like when the extremity is made to move, and the joints are much relaxed. In such cases the psoas and iliacus muscles are never completely paralyzed, and the aim of the surgeon is to utilize these muscles in enabling the patient to walk. In many cases the application of apparatus is sufficient. In others ankylosis may be established in the ankles and knees by operation. If ankylosis is established in these joints, the psoas and iliacus muscles become able to move the legs.

XXII. DISEASES AND INJURIES OF NERVES.

Diseases of Nerves.

Neuritis, or **inflammation of a nerve,** may be limited or be widely distributed (*multiple neuritis*). The first-mentioned form will here be considered. The causes of neuritis are traumatism, wounds, overaction of muscles, gout, rheumatism, syphilis, fevers, and alcoholism.

Symptoms.—The symptoms of neuritis are as follows: excessive pain, usually intermittent, in the area of nerve-distribution. The pain is worse at night, is aggravated by motion and pressure, and occasionally diffuses to adjacent nerve-areas or awakens sympathetic pains in the opposite side of the body. The nerve is very tender. The area of nerve-distribution feels numb and is often swollen. Early in the case the skin is hyperesthetic; later it may become anesthetic. The muscles atrophy and present the reactions of degeneration; that is, the muscles first cease to respond to a *rapidly* interrupted, and next to a *slowly* interrupted, faradic current; faradic excitability diminishes, but galvanic excitability increases. When, in neuritis, faradism produced no contraction, a slowly interrupted galvanic current which is so weak that it would produce no movement in the healthy muscle causes marked response in the degenerated muscle. In health the most vigorous contraction is obtained by closing with the — pole; in degenerated muscles the most vigorous contraction is obtained by closing with the + pole. When voluntary power returns, galvanic excitability declines; but power is often nearly restored before faradic excitability becomes manifest (Buzzard).

Treatment.—The treatment of neuritis consists of rest upon splints and the use of an ice-bag early in the case and a hot-water bag later. Blisters over the course of the nerve are of value, especially in traumatic neuritis. Massage and electricity must be used to antagonize degeneration. A descend-

* Centralbl. f. Chir., Oct. 17, 1896.

ing galvanic current allays pain to some extent. Deep injections of chloroform or cocain may allay pain. Treat the patient's general health, especially any constitutional disease or causative diathesis. The salicylate of ammonium or phenacetin may be given internally. In some cases nerve-stretching is advisable.

Neuralgia is manifested by violent paroxysmal pain in the trajectory of a nerve. This disease, unless it is exceedingly severe and persistent, is treated, as a rule, by the physician. Neuralgia of stumps and scars is a surgical condition, and is due to neuromata, or entanglement of nerve-filaments in a cicatrix. *Tic douloureux* and other intractable neuralgias require careful removal of any cause of reflex irritation. Causal reflex irritation may arise from disease of the stomach, eyes, teeth, uterus, nose, throat, etc. Tic douloureux has been treated by removal of the Gasserian ganglion; removal of Meckel's ganglion; ligation of the common carotid artery; neurectomy of terminal branches of the fifth nerve; division of motor nerves; injections of osmic acid (page 680); massive doses of strychnin (Dana) and purgatives (Esmarch). The distribution of the fifth nerve, the seat of pain in tic douloureux, is shown in Fig. 369.

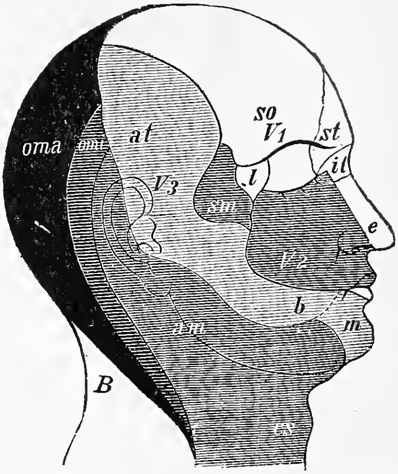


Fig. 369.—Distribution of the cutaneous sensitive nerves upon the head: *oma*, *omi*, The occipit. maj. and minor (from the N. cervical. II and III); *am*, N. auricular magn. (from N. cervic. III); *cs*, N. cervical. superfic. (from N. cervic. III); V_1, first branch of the fifth (*so*, N. supraorbit.; *st*. N. supratrochl.; *it*, N. infratrochl.; *e*, N. ethmoid.; *l*, N. lachrymal.); V_2, second branch of the fifth (*sm*, N. subcutan. malæ seu zygomaticus); V_3, third branch of the fifth (*at*, N. auriculo-tempor.; *b*, N. buccinator; *m*, N. mental.); *B*, posterior branches of the cervical nerves (Seeligmüller).

Treatment of Neuralgia of Stumps.—Excise the scar; find the bulbous end of the nerve and cut it off. Senn tells us to section the nerve by V-shaped cuts, the apex of the V being toward the body, and to suture the flaps together. Senn's method will prevent recurrence. In some cases reamputation is performed. In entanglement of a nerve in a scar remove a portion of a nerve above the scar and also the neuroma in the scar.

Wounds and Injuries of Nerves.

Section of Nerves (as from an incised wound).—After nerve-section the entire peripheral portion of the nerve degenerates and ceases structurally to be a nerve in a few weeks, but after many months, or even years, the nerve may regenerate. The proximal end degenerates only in the portion immediately adjacent to the section; it rapidly regenerates, and a bulb or enlargement composed of fibrous tissue and small nerve-fibers forms just above the line of section; this bulb adheres to the perineural tissues. The entire distal end degenerates, but new axis-cylinders form in this segment by pro-

liferation of the nuclei on the sheath of Schwann. Union of a divided nerve is brought about by the projection of axis-cylinders from the proximal end or from each end and the fusion of these cylinders. The nearer the two ends are to each other, the better the chance of union.

Symptoms.—Pronounced changes occur in the trajectory of a divided nerve. The muscles degenerate, atrophy, and shorten, and develop the reactions of degeneration. When union of the nerve occurs, the muscles are restored to a normal condition. If the nerve contains sensory fibers, complete anesthesia (to touch, pain, and temperature) usually follows its division; but if a part is supplied by another nerve as well as by the divided one, anesthesia will not be complete. Trophic changes arise in the paralyzed parts. Among these changes are muscular atrophy; glossy skin; cutaneous eruptions; ulcers; dry gangrene; painless felons; falling of the hair; brittleness, furrowing, or casting off of the nails; joint-inflammations; and ankylosis. Immediately after nerve-section vasomotor paralysis comes on, and for a few days the paralyzed part presents a temperature higher than normal. The diagnosis as to which nerve is cut depends upon a study of the distribution of paralysis and anesthesia.*

The Symptoms of Division of Nerves.—*Brachial Plexus.*—If one or more cords of the brachial plexus are divided, motor paralysis and anesthesia appear in the limb, the extent of the paralysis and the area of the anesthesia depending upon the cord or cords involved. It should be remembered that the inner cord of the brachial plexus gives origin to the ulnar nerve; the inner and outer cords give branches which fuse to form the median nerve. The posterior cord gives origin to the subscapular, the circumflex, and the musculospiral nerves. The outer cord gives origin to the external anterior thoracic and the musculo-cutaneous, as well as to the outer trunk of origin of the median.

Evulsion of the brachial plexus is sometimes effected by an injury, when the arm is not lost. Algernon T. Bristow ("Annals of Surgery," Sept., 1902) reports 3 cases of this rare injury, and has collected 24 undoubted instances. One of his own cases was operated upon the third day after the accident. In this case there was complete paralysis of the upper extremity, with the exception of the sensory area of the intercostohumeral and the circumflex nerves. The accident had been inflicted by the patient's forearm becoming entangled in a rope, which was pulled upon by a steam winch. On reaching the hospital he felt severe pain, referred to the arm. There was much swelling in the inner portion of the subclavian triangle, the left pupil was contracted, and it seemed likely that the nerves had been evulsed close to the intervertebral foramina. From the fact that sensation was preserved in the skin of the convexity of the shoulder down to the insertion of the deltoid, Bristow concluded that some fibers of the posterior cord of the plexus had escaped division; but when the operation was performed, this conclusion was found to be erroneous. An incision was made, and it was found that the plexus had given way at the point where the four cervical nerves and the last dorsal unite to form the three trunks. In order to reach the lower ends, it was necessary to saw the clavicle and divide the two pectoral muscles; and the torn ends of the nerve-trunks were found underneath the clavicle. Suturing

*See Bowlby on "Injuries of Nerves."

was performed. The ends of the sawn clavicle were sutured together, the wound was closed and dressed, and the arm was put up in Sayres's dressing.

This article of Bristow's is of extreme interest. He discusses the injury to the sympathetic and the reason that sensation was preserved over the area usually supplied by the circumflex. After the performance of this operation sensation over the entire upper arm returned. We agree with Bristow that after such an injury early operation is the only thing that offers any prospect of the return of function. I myself once operated upon a patient that had developed paralysis, motor and sensory, after violent stretching of the arm. In the light of Bristow's case I assumed that evulsion of the plexus had probably taken place. Incision disclosed the fact that the plexus was intact but was surrounded with dense scar-tissue. This tissue was removed, so as to loosen the nerves; but I have lost track of the patient, and do not know the result. My patient was operated upon many months after the injury. It is well to bear in mind that in an injury of the supraclavicular division of the brachial plexus there will probably be palsy of the great serratus muscle.

Brachial Birth Palsy.—It has been pointed out by Clark, Taylor, and Prout ("Am. Jour. Med. Sciences," Oct., 1905) that brachial birth palsy results from tension on the nerve-trunks by overstretching during delivery, the nerve-sheath first rupturing and then the nerve-fibers. When the sheath ruptures hemorrhage occurs, fibrous tissue forms, and the scar presses on the intact, slightly stretched, or actually lacerated nerve and prevents repair. The authors tell us that the fifth cervical root first gives way, then the sixth, and so on down the plexus if there is sufficient force. In the mild cases the fifth root alone suffers. They call it brachial birth palsy, or *laceration palsy*, and sum up the symptoms in a severe case as follows: The arm hangs powerless; abduction at the shoulder is impossible because of deltoid and supraspinatus palsy; the forearm is extended and flexion is impossible because of biceps, brachialis anticus, and supinator longus palsy; palsy of supinator brevis and biceps causes pronation of hand; there is inward rotation of the humerus because of palsy of the supraspinatus, infraspinatus, and teres minor.

Brachial birth palsy is manifest soon after its infliction by evidences of pain on handling the extremity, the pain being due to neuritis (authors above quoted). Medical treatment is relied on for one year and then, if improvement is not manifest, operation is indicated (page 685).

Posterior Thoracic Nerve.—Division of this nerve causes paralysis of the serratus magnus muscle, which is made evident by eversion and rotation of the scapula when the arm is taken forward.

Suprascapular Nerve.—Division of this nerve produces some anesthesia over the scapula and paralysis of the supraspinatus and the infraspinatus muscles.

Circumflex Nerve.—Division of the circumflex nerve produces paralysis of the deltoid muscle, so that it becomes impossible to lift the arm to a right angle with the body. There is some slight retention of power in the anterior fibers, which are supplied by the anterior thoracic nerve. The skin over the lower part of the muscle is usually anesthetic.

Musculocutaneous Nerve.—Division of this nerve produces paralysis of the biceps and of the brachialis anticus muscles. This palsy becomes especially evident when the forearm is supinated, because in this position the

supinator longus can no longer act as a flexor of the elbow. There is anesthesia of the radial side of the forearm, anteriorly and posteriorly.

The Musculospiral or Radial Nerve.—Division of this nerve high up near the plexus causes paralysis of the extensor muscles of the elbow and the wrist, of the supinators, and of the long extensors of the thumb and fingers. When divided near the middle of the humerus, the triceps usually, but not invariably, escapes. If the injury is below the branch going to the supinator longus, that muscle will escape; otherwise it will become paralyzed. The extensor palsy causes wrist-drop and loss of the power of extending the first phalanges of the fingers and thumb; and, as Gowers has pointed out, flexion is reduced to one-third of the normal, the flexors having lost power "from the loss of antergic support." As a rule, in musculospiral palsy there is loss of supination. Sensibility is sometimes greatly affected, and sometimes very slightly. Anesthesia rarely occurs in the upper arm; and even in the hand sensation may be normal, or nearly so. Fig. 370 shows the position

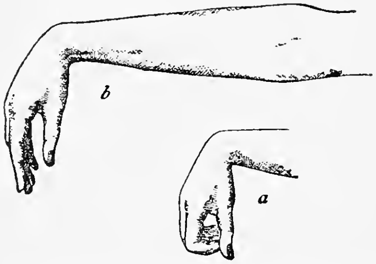


Fig. 370.—Paralysis of musculospiral nerve after fracture of the humerus ("wrist-drop"); but when fingers have been flexed into palm, *a*, they can be extended, *b*, at first interphalangeal joints by lumbricals and interossei, which are supplied by the ulnar and median nerves (Erichsen).

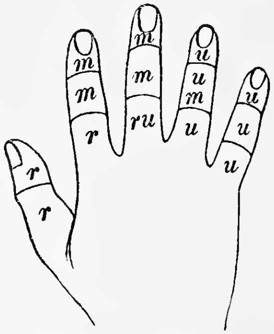


Fig. 371.—Distribution of sensory nerves on the backs of the fingers: *r*, Musculospiral or radial nerve; *u*, ulnar nerve; *m*, median nerve (Krause).

of the parts in musculospiral palsy and Figs. 371 and 375 the sensory distribution of the nerve.

The Median Nerve.—After division of the median nerve there is paralysis of the pronators; the flexor carpi radialis; the finger flexors, except the ulnar portion of the deep flexor; the abductors, and the flexors of the thumb; and the two radial lumbricales. The forearm can be placed in a position midway between pronation and supination; but further pronation cannot be voluntarily effected. In executing flexion of the wrist a strong deviation toward the ulnar side takes place. The thumb is in a position of extension and abduction, and cannot be brought into apposition with the finger-tips. The second phalanges of the fingers cannot be flexed on the first, and the distal phalanges of the first and second fingers cannot be voluntarily flexed. The corresponding phalanges of the third and fourth fingers can be flexed, this being accomplished by the unparalyzed ulnar half of the deep flexor. Flexion of the first phalanges is still possible, as it is accomplished by means of the interossei. The

extensor action of the interossei muscle upon the middle and distal phalanges, being unopposed, may eventually cause subluxation. The sensory distribution of the median nerve is shown in Figs. 371, 372, 373, and 375. It is the sensory nerve of the radial side of the palm, the front of the thumb, the first and second fingers and half of the third finger, and the back of the last

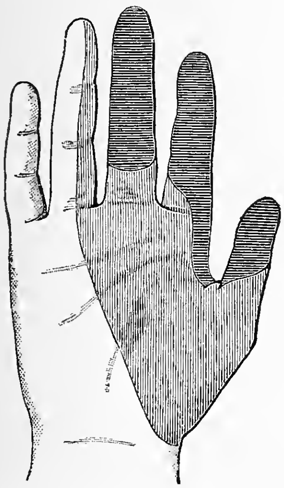


Fig. 372.—Section of median nerve; areas of anesthesia (heavy shading) and of dysesthesia (light shading) on palmar surface of hand (Bowlby).

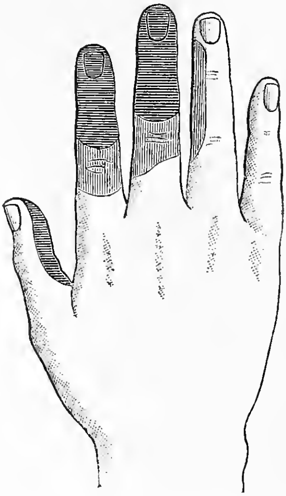


Fig. 373.—Section of median nerve; regions of anesthesia and dysesthesia on dorsal surface of hand (Bowlby).

phalanx of the index and the middle finger (Gowers). The sensory changes after median paralysis are quite variable—sometimes wide-spread and complete, at other times trivial, and occasionally absent. Gowers says that if there is anesthesia it is usually of the palmar surface, and may also occur on the dorsal aspect of the ends of the first two fingers.

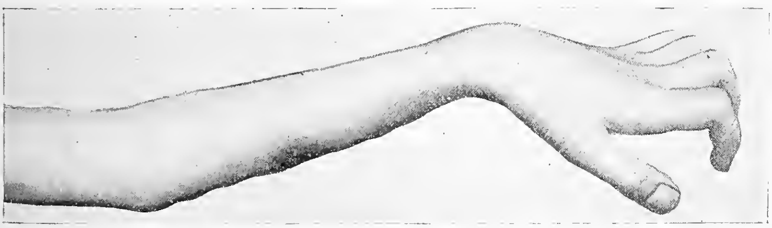
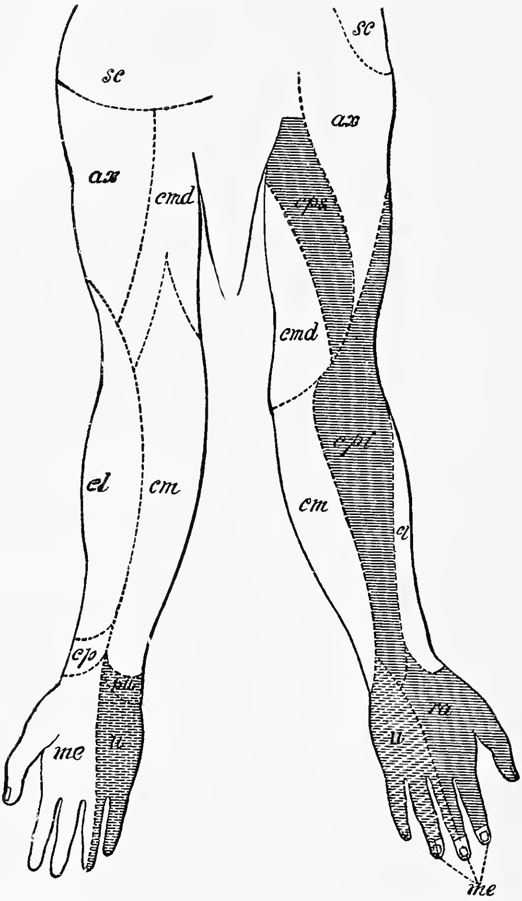


Fig. 374.—Division of ulnar nerve.

The Ulnar Nerve.—When the ulnar nerve is divided, there is paralysis of the flexor carpi ulnaris, of the ulnar portion of the deep flexor, of the muscles of the little finger, of the abductor pollicis, and of the inner end of the flexor brevis pollicis (Gowers). It becomes impossible to adduct the thumb, and the majority of the movements of the little finger are abolished. Flexion of the fingers is impossible at the first joints, and extension is impossible at the

other joints; but, as Gowers points out, the loss is slighter in the first two fingers than in the others, because the lumbricales of the first two fingers are supplied by the median nerve. Interosseal flexion is impossible, and the opponents of the interossei, acting without normal antagonism, contract and pro-



Anterior surface. Posterior surface.

Fig. 375.—Distribution of the cutaneous nerves to the shoulder, arm, and hand. The region of the N. radialis is represented by the unbroken hatched line, that of the N. ulnaris by the broken hatched lines. *a*, Anterior, *b*, posterior surface; *sc*, Nn. suprascapular (plexus cervicalis); *ax*, chief branch of N. axillar.; *cps*, *cpi*, Nn. cutanei post. sup. and inf. (from N. radialis); *ra*, terminal branches of N. radialis; *cm*, *cl*, Nn. cutanei medius (also to the plexus) and lateralis (chiefly to the N. medianus); *cp*, N. cutan. palmar., N. rad.; *cmd*, N. cutan. medialis; *me*, N. medianus; *u*, N. ulnaris; *epu*, N. cutan. palm. ulnaris (Henle).

duce what is known as a *claw-hand* (Figs. 374 and 376), a condition in which the first phalanges are overextended and the others are flexed. The sensory loss in ulnar paralysis is extremely variable. The sensory distribution is to the ulnar side of the hand, both back and front, involving the little finger, the ring-finger, and the ulnar half of the middle finger (Figs. 371, 375, and 377).

Lumbar Plexus.—The lumbar plexus supplies the cutaneous surface of the lower portion of the abdomen, of the front and the sides of the thigh, and of the inner portion of the leg and foot (Fig. 378). It innervates the flexors and adductors of the hip-joint, the extensors of the knee, and the cremaster muscle. The branches sent to the leg are the obturator and the anterior crural nerves.

Sacral Plexus.—The sacral plexus supplies the extensors and rotators of the hip, the knee-flexors, and all the muscles of the foot; also the skin of the gluteal region, the back of the thigh, the outer portion and the posterior part

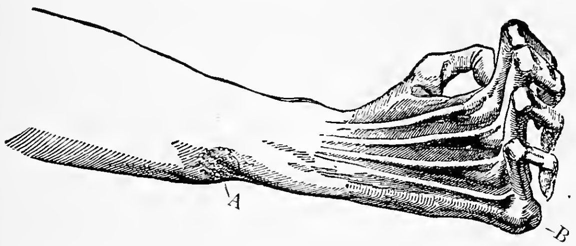


Fig. 376.—Paralysis of ulnar nerve from wound at A; contracture of common extensor with posterior luxation of first phalanges; B, head of metacarpal bone (Duchenne).

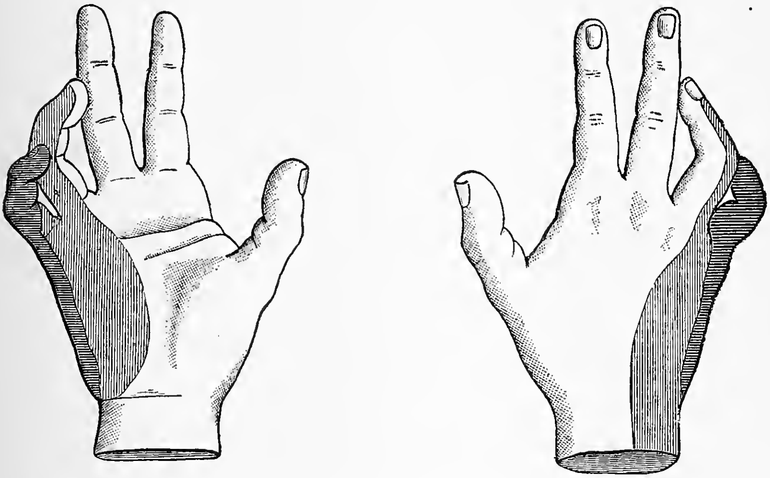


Fig. 377.—Showing sensory loss and ordinary position in injuries of the ulnar nerve (Bowlby).

of the lower leg, and most of the foot (Gowers) (Fig. 378). Its chief branches are those to the external rotators of the hip—the gluteal nerve, the small sciatic, and the great sciatic.

The Anterior Crural Nerve.—When this nerve is divided, the extensor muscles of the knee are paralyzed. The psoas muscle is not affected, even if the nerve is divided within the abdomen; but high division may produec paralysis of the iliacus muscle. In anterior crural palsy the skin is anesthetic over almost the entire thigh, the inner surface of the leg and foot, and the inner sides of the first and second toes (Fig. 378).

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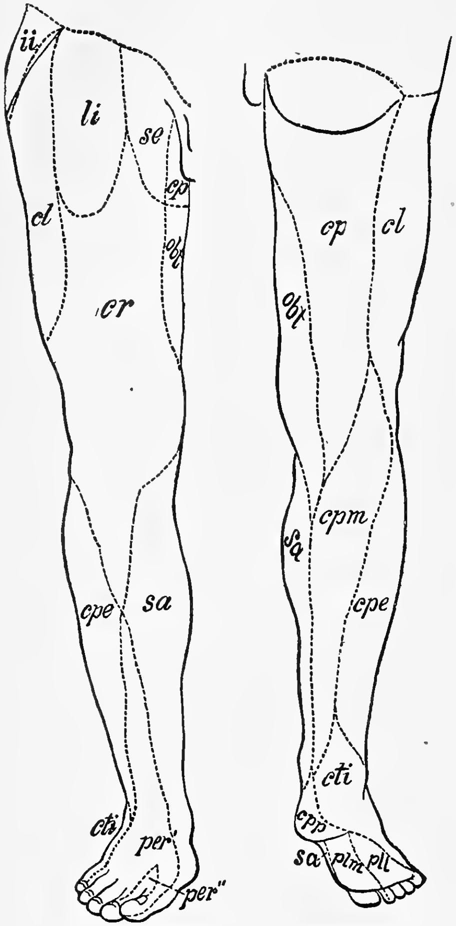
The Obturator Nerve.—In obturator palsy the adductor muscles of the thigh are paralyzed, and, in consequence, the patient is unable to cross one leg over the other. Gowers points out that external rotation of the thigh is also interfered with.



Anterior surface. Posterior surface.

Fig. 378.—Distribution of the cutaneous nerves of the lower extremity: *ii*, N. ilio-inguinal. (plex. lumb.); *li*, N. lumbo-inguinal. (to the genitocrural, plex. lumbal.); *se*, N. spermat. ext. (to the genitocrural); *cp*, N. cutan. post. (plex. ischiad.); *cl*, N. cutan. lateral. (plex. lumb.); *cr*, N. cruralis (plex. lumbal.); *obt*, N. obturator. (plex. lumb.); *sa*, N. saphen. (plex. lumbal.); *cpe*, N. commun. peron. (N. peron. tibial.); *cti*, N. commun. tibial; *per'*, *per''*, N. peronæi ram. superfic. et prof.; *cpm*, N. cutan. post. med. (plex. ischiad.); *cpp*, N. cut. plant. propr. (N. tib.); *plm*, *pll*, N. plantar. medial. et lateral. (N. tib.) (Henle).

The Superior Gluteal Nerve.—The division of this nerve paralyzes the gluteus medius and the gluteus minimus muscles, and there is "loss of abduction and circumduction of the thigh" (Gowers).

The Small Sciatic Nerve.—Division of this nerve paralyzes the gluteus maximus muscle and produces anesthesia of the upper half of the calf of the leg and of the middle third of the back of the thigh (Gowers) (Fig. 378).

The Great Sciatic Nerve.—If this nerve is divided near the sciatic notch, there is a paralysis of the flexor muscles of the leg. These muscles, as Gowers points out, are also extensors of the hip. There is likewise paralysis of all the muscles below the knee. If, however, the injury is below the upper third of the thigh, there is no paralysis of the flexors of the leg. If the nerve is damaged on a level below the small sciatic, there is anesthesia of the outer portion of the leg, of the sole of the foot, and of most of the dorsum of the foot (Fig. 378).

The External Popliteal Nerve.—When this nerve is damaged, there is paralysis of the tibialis anticus muscle, the extensor longus digitorum, the extensor brevis digitorum, and the peronei; and the patient is unable to flex the ankle and extend the first phalanges of the toes. When he tries to walk, he cannot lift the foot from the ground; and eventually there is the development of talipes equinus

(Gowers). The anesthesia is manifest on the outer portion of the anterior surface of the leg, and also on the dorsum of the foot (Fig. 378).

The Internal Popliteal Nerve.—Damage to this nerve paralyzes the posterior tibial muscle, the flexor longus digitorum, the muscle of the calf, the popliteus muscle, and the muscles of the plantar surface of the foot. The toes become flexed at the two distal joints, and extended at the proximal joints. Walking is greatly interfered with. There is loss of the power of rotating the flexed leg inward, if the damage is above the branch to the popliteus muscle; and extension of the ankle-joint is lost. As the consequence, talipes calcaneus develops (Gowers). The anesthesia is variable, but usually involves the sole of the foot and the outer surface and lower portion of the back of the leg (Fig. 378).

The Plantar Nerves.—Division of the internal plantar nerve paralyzes the short-toe flexor, the two inner lumbricales, and the plantar muscles of the great toe, except the adductor (Gowers). There is anesthesia of the inner portion of the sole of the foot and of the plantar surface of the three inner toes and of half of the fourth toe (Fig. 378).

Division of the external plantar nerve causes paralysis of the muscles of the little toe, of the adductor of the great toe, of all the interossei, of the two outer lumbricales, and of the flexor accessorius (Gowers). There is anesthesia of the skin of the outer half of the sole of the foot, of the little toe, and of half of the fourth toe (Fig. 378).

Treatment.—In all recent cases of nerve-section suture the ends of the divided nerve. In 123 cases of *primary suture*, 119 were cured in from one day to one year (Willard). The return of sensation may be rapid or may be slow; muscular power returns more slowly than sensation. If the patient is not seen until long after the accident, incise and apply sutures (*secondary sutures*); if the nerve cannot be found, extend the incision, find the trunk above and trace it down, and find the trunk below and follow it up. In 130 cases of secondary suture 80 per cent. were more or less improved (Willard). Even after primary suture loss of function is bound to occur for a time. After secondary suture sensation may return in a few days, but it may not return until after a much longer period; in any case muscular function is not restored for months. After partial section of a nerve the ends should be sutured. In performing secondary suture it may be necessary to effect "*lengthening*" in order to approximate the ends. *Transplantation* of a portion of nerve is sometimes practised (*implantation* or *anastomosis*). Nerve-grafting is bridging the gap by means of a portion of nerve from one of the lower animals or from a recently amputated human limb. Nerve-transplantation may fail utterly; it may be followed by great improvement; but absolute and perfect restoration of function cannot be obtained. R. Peterson * has made a study of the 20 recorded cases of nerve-grafting. Eight of the operations were primary and 12 were secondary. The periods after the injury at which operation was performed varied from forty-eight hours to a year and a quarter. Four of the 8 primary cases improved. Eight of the 12 cases of secondary operation showed improvement in motion or sensation. The distance between the nerves did not seem to affect the results. No case recovered completely, but in one case sensation returned completely and only the abductors of the

* Amer. Jour. of Med. Sciences, April, 1899.

thumb remained weak. In most cases benefited sensation returned by the tenth day and motion within two and a half months. In one of the successful cases, that of A. W. Mayo Robson,* the spinal cord of a rabbit was used.

Pressure upon nerves may arise from callus, scars, a dislocated bone, a tumor, or an external body.

The **symptoms** may be anesthetic, paralytic, or trophic.

The **treatment** is as follows: Remove the cause (reduce a dislocated bone, chisel away callus, excise a scar, etc.); then employ massage, douches, exercise, and electricity.

Dislocation of the Ulnar Nerve at the Elbow.—This condition is very rare. It may occur as a complication of a fracture or a dislocation, or as an uncomplicated condition. It may be produced by violence or by muscular effort, which ruptures the fascia, the function of which is to retain the nerve back of the inner condyle of the humerus. In some cases the symptoms are slight and transitory, the nerve functionating well in its new situation. As a rule, there are pain, numbness, or anesthesia of the ulnar trajectory, some stiffness of the elbow, and stiffness of the little finger and ring-finger. The nerve can be felt in front of the inner condyle of the humerus. In some cases neuritis follows, with trophic changes.

Treatment.—Expose the nerve by an incision, incise the fibrous tissue back of the inner condyle, and press the nerve into the bed prepared for it and hold it in place by sutures of kangaroo-tendon passing through the triceps tendon. Wharton advises suturing also "the margin of the fascial expansion of the triceps tendon superficial to the nerve." †

Contusion of Nerves.—The **symptoms** of contusion of nerves may be identical with those of section. Sensation or motion, or both, may be lost. The case may recover in a short time, or the nerve may degenerate as after section.

The **treatment** at first is rest, and later electricity, massage, frictions, and douches.

Punctured Wounds of Nerves.—The **symptoms** of punctured wounds of nerves may be partly irritative (hyperesthesia, acute pain, and muscular spasm) and partly paralytic (anesthesia, muscular wasting, and paralysis).

The **treatment** after the puncture has healed is the same as that for contusion.

Operations upon Nerves.

Neurorrhaphy, or Nerve-suture.—When a nerve is completely or partially divided by accident, it should be sutured. The instruments required are an Esmarch apparatus, a scalpel, blunt hooks, dissecting forceps, hemostatic forceps, curved needles or sewing needles, a needle-holder, and catgut, silk, or kangaroo-tendon. In primary suture render the part bloodless and aseptic. Enlarge the incision if necessary. If the ends can readily be approximated, pass two or three sutures through both the nerve and its sheath and tie them (Figs. 379 and 380). If the ends cannot be approximated,

* Amer. Jour. of Med. Sciences, April, 1899.

† A report of fourteen cases of dislocation of the ulnar nerve at the elbow, by H. R. Wharton, Amer. Jour. of Med. Sciences, Oct., 1895.

stretch each end and then suture. Remove the Esmarch band, arrest bleeding, suture the wound, dress antiseptically, and put the part in a relaxed position on a splint. After union of the wound remove the splint and use massage, frictions, electricity, and the douche. The operation in some instances fails, but in many cases succeeds. In some few cases sensation returns in a few days, but in most cases does not return for many weeks or months. Sensation is restored before motor power. *Secondary suture* is performed upon cases long after division of a nerve. The part is rendered aseptic and bloodless; an incision is made; the bulbous proximal end is easily found and loosened from its adhesions; the shrunken distal end is sought for and loosened (it may be necessary to expose the nerve below the wound and trace its trunk upward); the entire bulb of the proximal end is cut off; about one-quarter of an inch of the distal end is removed (Keen); each end is stretched, and the ends are approximated and sutured together. If stretching does not permit of approximation, adopt the expedient shown in Fig. 380, *d*, or in Fig. 381. This operation is *neuroplasty* by the *flap method*. Another method is to make a bridge of strands of catgut running from one divided end to the other. We speak of this plan as *suture à distance* (Fig. 380, *e*). The catgut bridge supports the growing reparative material. Guelliot suggested *tubulization*, that is, erecting barriers along the path of reparative material to keep surrounding tissues from entering and blocking it. *Implantation*, or *anastomosis*, is advisable in some cases. Letiévant attaches the cut end of the

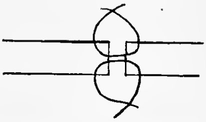


Fig. 379.—Nerve-suture.

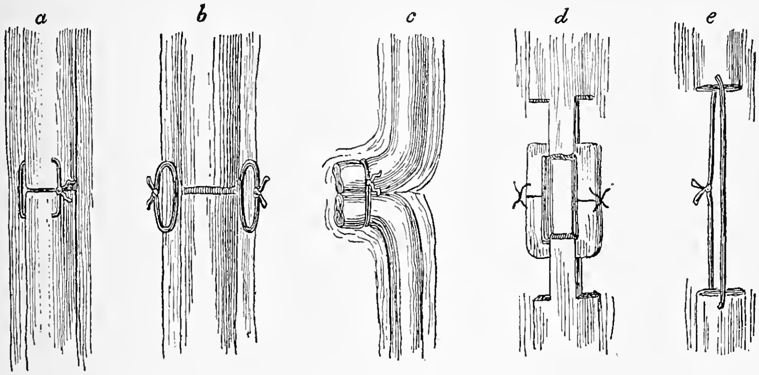


Fig. 380.—Nerve-suture: *a*, Direct; *b*, perineurotic; *c*, paraneurotic; *d*, *e*, neuroplasty (Senn).

peripheral portion of a divided nerve to an adjacent uncut nerve. Allis suggested shortening the limb by resecting a piece of bone and then suturing the ends of the nerves together. The operation has been carried out successfully by Keen, Rose, and others.

Nerve-grafting is practised by some. A. W. Mayo Robson used the spinal cord of a rabbit to fill a gap between the ends of the divided median nerve of a man. The restoration of function was almost complete. Some surgeons have grafted in bits of nerve obtained from a recently amputated

limb. It makes no difference whether the grafted nerve was motor or sensory or mixed. The results of grafting are seldom good. Chas. A. Powers ("Transactions of the American Surgical Assoc.," 1904) collected 22 cases from literature, 20 from Peterson's paper, 1 case of Durante's, and 1 of his own. In this series there were 3 good results and 3 "fair" results. The bit of nerve grafted does not participate in repair—it is a mere bridge, and acts as does the suture à distance.

Neurectasy, Neurotomy, and Neurectomy.—*Neurectasy*, or nerve-stretching, may be applied to motor, sensory, or mixed nerves. A nerve can be stretched about one-twentieth of its length. Neurectasy has been employed for neuralgia, neuritis, muscular spasm, hyperesthesia, anesthesia, painful ulcer, perforating ulcer, and the pains of locomotor ataxia. The operation, which was once the fashion, seems to benefit some cases, but it is not now thought so highly of as formerly. The incision for neurectasy is identical with the incision for neurectomy or neurotomy of the same nerve. *Neurotomy*, or section of a nerve, is performed only upon small and purely sensory nerves. It is performed chiefly for peripheral neuralgia or for some other painful malady. It is useless, because sensation, as a rule, soon returns. Paget saw complete return of sensation in four weeks after division of the median nerve. Corning endeavers to prevent this regeneration by inserting oil between the ends. He uses oil of theobroma containing enough paraffin to make the melting-point 105° F. The oil is melted, is injected around the nerve, and cold is applied. The nerve is now sectioned with a canaliculated knife, the ends are separated widely, more oil is injected, and cold is again applied. The theory is that this oil, which is solid at the temperature of the body, devitalizes the nerve at the point of section and acts as a barrier to the passage of regenerating fibers. This method has been applied especially in cervicobrachial neuralgia.* *Neurectomy*, or excision of a portion of a nerve-trunk, is applicable only to sensory nerves and to painful affections.

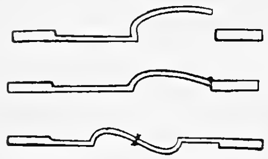


Fig. 381.—Suture of a nerve by splitting the ends (Beach).

Sympathectomy.—*Jonnesco's Operation.*—It has long been known that division of the sympathetic nerve in the neck may produce important changes in the eye and in the cerebral circulation. In 1893 Jaboulay divided the sympathetic on each side, for the purpose of treating epilepsy. The removal of the ganglia of the sympathetic was proposed by Baracz; and the operation was first performed by Jonnesco, in 1896, for epilepsy. The operation is performed by some surgeons for epilepsy, for exophthalmic goiter, and for glaucoma. In operating for glaucoma the superior cervical ganglion on each side is removed, as it is from this that the sympathetic fibers that pass to the eye are derived. If the operation is done at all, it should be a bilateral operation.

The operation is used in epilepsy on the theory that there is an anemic condition of the brain in this disease, which is corrected by producing a hyperemia, and that the hyperemia improves cerebral nutrition. The operation in epilepsy is largely theoretical, although Jonnesco claims 12 per cent.

* Medical Record, Dec. 5, 1896.

of cures in a large number of operations. In exophthalmic goiter there seems to be some distinct evidence that the operation may be beneficial. Personally, I have not employed it in epilepsy; and, at the present time, I should not be inclined to do so. In exophthalmic goiter, if any operation is necessary, I should perform partial thyroidectomy; but in progressive glaucoma, which is always so absolutely hopeless, the operation is a justifiable procedure and occasionally seems to have a distinct influence in retarding the development of the disease.

The incision should be made along the posterior margin of the sternocleidomastoid muscle. I have become convinced, in performing two operations of this kind and through studies made upon the dead body, that the ganglion may be more easily reached from behind the sternocleidomastoid than from in front of it. The internal jugular vein and the carotid artery are lifted upward and forward; and the superior ganglion will usually adhere to the under portion of the carotid sheath, and be lifted up with it. Theoretically, it is not necessary to open the carotid sheath in this operation, but, practically, this had better be done, so that one may, without any possibility of doubt, distinguish between the pneumogastric and the sympathetic nerve. The moment the nerve is cut, the pupil on that side will contract.

Stretching of the Sciatic Nerve.—Some surgeons stretch the sciatic nerve by anesthetizing the patient and holding the leg and thigh in line, strong flexion being made upon the hip, the entire lower extremity being used as a lever (Keen). This method, which has caused death, inflicts needless damage, and stretching after an incision has been made is safer and better. The instruments required are a scalpel, hemostatic forceps, dissecting forceps, a dissector, retractors, and a scale with a handle and a hook. The patient lies prone, the thigh and legs being extended. An incision four inches in length is made a little external to the middle of the thigh, and going at once through the deep fascia; the biceps muscle is found and is drawn outward; the nerve is discovered between the retracted biceps on the outside and the semitendinosus on the inside, resting upon the adductor magnus muscle. The nerve, which is caught up by the finger, is first pulled down from the spine and then up from the periphery, and finally the hook of the scale is inserted beneath the trunk and the nerve is stretched to the extent of forty pounds. Very rarely is even a single ligature needed. The wound is sutured and dressed. If the incision is made at a higher level below the gluteofemoral crease, the sciatic nerve will be found just by the outer border of the biceps.

Neurectomy of the Infra-orbital Nerve.—This operation was first performed by Abernethy in 1793. The instruments required in this operation are a scalpel, dissecting forceps, aneurysm needle, hemostatic forceps, blunt hooks, a dissector, and metal retractors. The patient lies upon his back, the head being a little raised by pillows. The surgeon stands to the outside of and faces the patient. A curved incision one and a half inches long is made below the lower border of the orbit. The nerve lies in a line dropped from the supra-orbital notch to between the two lower bicuspid teeth. The nerve is found upon the levator labii superioris muscle. A piece of silk is passed under the nerve by an aneurysm needle and firmly fastened. The upper border of the incision is drawn upward; the periosteum of the floor of the orbit is elevated and held by a retractor; the roof

of the infra-orbital canal is broken through; the nerve is picked up far back with the blunt hook and is divided with scissors, and the entire nerve is drawn out by making traction upon the silk. The bleeding in the orbit is checked by pressure. The wound is stitched without drainage.

Neurectomy of the Supra-orbital Nerve.—Before sterilizing the parts shave off the eyebrow. The instruments required and the position of the patient are as for the operation upon the infra-orbital nerve. A curved incision one inch long discloses the nerve as it emerges from the supra-orbital notch or foramen at the junction of the inner and middle thirds of the eyebrow. The nerve is pulled forward and cut off above and below.

Neurectomy of the Inferior Dental Nerve.—The instruments are the same as for any other neurectomy, and in addition a chisel, a mallet, and a rongeur forceps. Make a curved incision around the angle of the jaw. Lift the supramaxillary branch of the facial nerve downward (Kocher). Separate the masseter muscle with a periosteum-elevator and slight touches with the knife. Chisel an opening in the center of the ascending ramus (Velpeau's rule). This opening exposes the beginning of the dental canal. If necessary, the opening may be enlarged with a rongeur. Pull the nerve out with a hook and remove a piece from it.

Extracranial Operation for Neuralgia of the Fifth Nerve.—The operation for removal of the Gasserian ganglion is difficult, bloody, and dangerous. Removal of portions of the pain-haunted nerve-trunks sometimes cures the condition and often ameliorates it for a considerable time. The injection of osmic acid into the peripheral nerves may actually cure or secure prolonged relief. The serious operation of removing the ganglion may be performed if peripheral operations fail or in violent and intractable cases of long standing in which pain is felt in more than one branch. Removal of nerves by ordinary neurectomy often gives comfort for a few months, but rarely gives prolonged relief. If we seek striking benefit by an extracranial operation, it must be thoroughly done.

Injection of Osmic Acid.—This method was suggested by Bennett, of London, in 1897. Osmic acid had been used for many years in a sort of haphazard way, being thrown into tissues about the nerves by means of a hypodermatic syringe. Bennett suggested exposure of the nerve and the injection of 5 to 10 minims of a 1 per cent. solution. Acid when so used actually destroys nerve-fibers, and a considerable amount of fibrous tissue forms which intercepts regenerating fibers. It is probable that secondary degenerative changes occur in the nerve-trunks, and it is possible that they occur in the ganglion. Murphy warmly advocates the method. It certainly produces immediate relief by causing immediate anesthesia, but whether such relief is permanent it is as yet too early to say. I have used it in several cases with great satisfaction. In one case in which I exposed the ganglion I injected the ganglion, and the result seems to be the same as if I had removed the ganglion. In neuralgia of the fifth nerve the painful nerve or nerves should be exposed, and from 5 to 10 minims of a 2 per cent. solution of osmic acid injected into several different parts of the nerve and also between the nerve-sheath and the bony canal (Murphy).

Rose's Method of Neurectomy.*—This operation is a modification of

*See article by Wm. Rose, "Practitioner," March, 1900.

the Braun-Lossen method, and is employed when the second division of the fifth nerve is the seat of pain. Besides the instruments laid out for any ordinary operation, the surgeon requires chisels, fine saws, blunt hooks, periosteum separators, silver wire (No. 22), and drills. The infra-orbital nerve is exposed by an incision, a ligature is tied around it, the roof of the infraorbital canal is opened by a chisel, and the nerve is traced back as far as possible. The wound is then packed temporarily with gauze. The next step in the operation is to open a way into the sphenomaxillary fossa (Fig. 382). The knife is inserted slightly below the external angular process of the frontal bone, is carried back along the zygoma, down in front of the ear to just above the angle of the jaw, and then forward for two inches. This flap, which is composed of skin and subcutaneous fat only, is dissected forward, and Steno's duct and branches of the facial nerve are not damaged. The flap is wrapped in

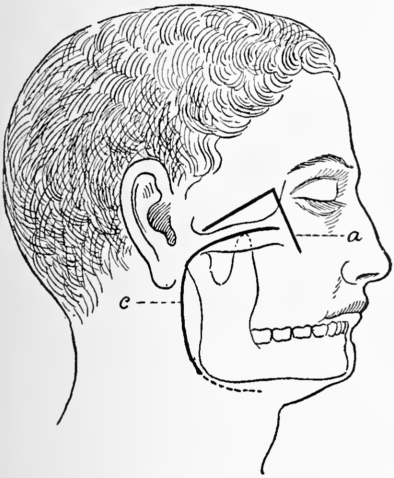


Fig. 382.—*a*, The Braun-Lossen incision; *c*, Rose's incision for reaching the sphenomaxillary fossa (Rose).

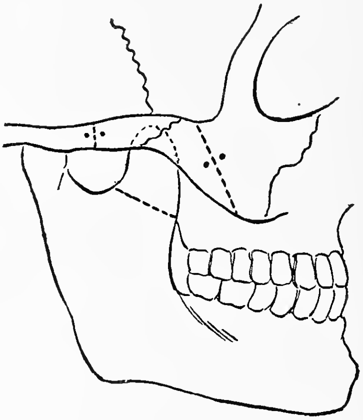


Fig. 383.—Lower jaw and zygoma. Drill-holes and saw-cuts are shown (Rose).

gauze and temporarily stitched to the side of the nose. The zygoma is exposed by a transverse incision. At the root of the zygoma two holes are drilled one-fourth of an inch apart, and two more holes one-fourth of an inch apart are drilled through the zygomatic process of the malar bone. The zygoma is then divided by a saw (Fig. 383). The posterior saw line runs between the two drill-holes at the root of the zygoma. The anterior cut passes between the two anterior drill-holes. The direction of the first cut is directly downward. The direction of the second cut is downward and forward from above. The arch is freed and detached downward and backward. The exposed tendon of the temporal muscle is retracted backward. The removal of a little fat exposes the pterygomaxillary fossa. The internal maxillary artery is exposed, two ligatures are applied, and the vessel is divided between them. The finger feels for the sphenomaxillary and pterygomaxillary fissures. The external pterygoid muscle is separated from the greater wing of the sphenoid and from

the root of the external pterygoid process. On the edge of the greater wing of the sphenoid a long prominence is usually detectable. It overhangs the sphenomaxillary fossa and should be cut away by the use of a chisel. The superior maxillary nerve is lifted on a blunt hook, is grasped with forceps, and is twisted off as near the ganglion as possible (Fig. 384). The distal end is drawn upon, and the nerve, having been previously loosened, is drawn back through the infra-orbital canal. The zygomatic arch is wired in place, the temporal fascia is sutured with buried sutures, and the skin-wound is closed. If the pain involved not only the second division, but also the third division, the operation previously described should be performed first, and the third division should be attacked a few weeks later. The third division is reached by removing the coronoid process. The inferior dental and lingual nerves are found, and are traced up to the foramen ovale, and are twisted off close to the ganglion, and the distal portions are removed.

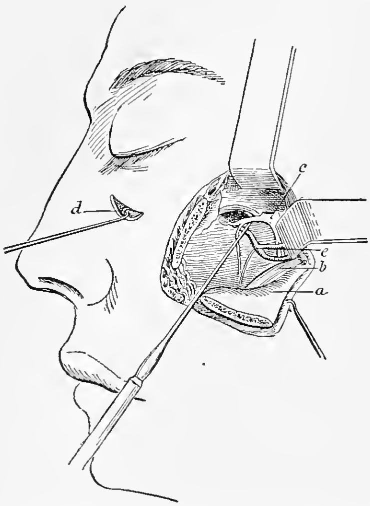


Fig. 384.—*a*, The zygomatic arch, turned down after sawing; *b*, tendon of the temporal muscle retracted; *c*, superior maxillary nerve and Meckel's ganglion; *d*, infra-orbital nerve emerging from canal; *e*, internal maxillary artery.

Removal of the Gasserian Ganglion.—This formidable procedure was first suggested by J. Ewing Mears in 1884 and was first performed by Wm. Rose in 1890. This operation is dangerous, bloody, and difficult, and is only undertaken in very severe cases of tic douloureux, and in cases upon which less grave procedures have failed. The operation usually cures the pain if the patient recovers from the actual procedure. The mortality is from 10 to 15 per cent. Carson collected 100 cases, Murphy and Neff 42 cases. The mortality in this group of 142 cases was 15 per cent. Most of the cases reported by Murphy and Neff were operated upon during or after 1899, and in this group the mortality was 10 per cent. ("Progressive Medicine," March, 1903). In Lexer's series of 201 cases, referred to below, the mortality was 17 per cent. In many cases a perfect cure is obtained. In some few the pain returns upon the side operated upon. Occasionally it arises on the side not operated upon. In some cases ulceration of the cornea follows operation. Such ulceration may be trivial, may result in opacity, or may destroy the eye. Paralysis of the abducens occurs in some cases. The hemorrhage may be so profuse as to require packing of the wound and suspension of the operation for a few days. The bleeding may come from the meningeal artery, from the sinus, or from the veins of Santorini. Lexer ("Arch. f. klin. Chir.," Bd. lxv, H. 4) gives a table of 201 cases. Of the survivors, 93.4 per cent. were apparently cured. In two-thirds of the cases the trouble was right-sided. In 10 the operation was temporarily abandoned because of hemorrhage. The experience of surgeons in general is that after the removal of the ganglion

there is apt to be some atrophy of the tongue and the eye usually becomes insensitive and watery.

The Hartley Operation for Removal of the Gasserian Ganglion.— This operation was first performed by Hartley in 1891, five months before Krause performed it. The surgeon is provided with the instruments for osteoplastic resection of the skull. Krause and others employ a surgical engine. Keen uses chisels and a mallet. Cushing makes part of his flap with the DeVilbiss forceps and part with a Gigli saw. Special retractors, various hooks, scalpels, a dry dis-

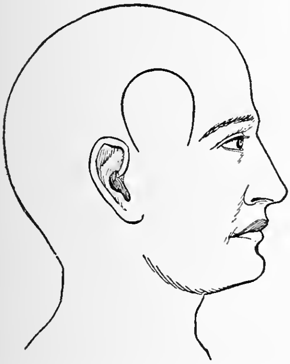


Fig. 385.—Hartley's osteoplastic flap in removal of Gasserian ganglion (Tiffany).

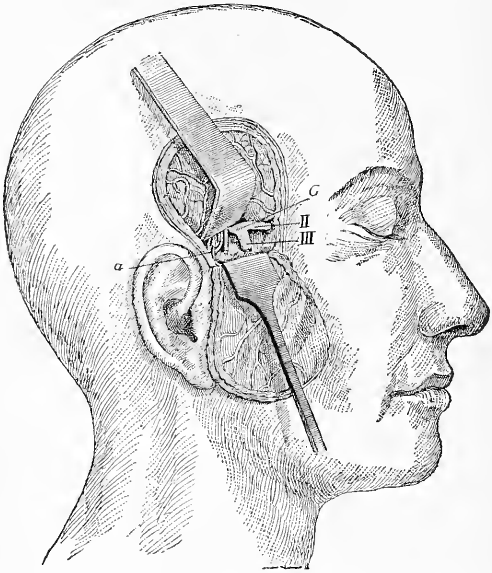


Fig. 386.—Removal of Gasserian ganglion; *a*, Middle meningeal artery: II, ophthalmic division; III, submaxillary division; *G*, ganglion (Krause).

sector, dissecting and hemostatic forceps, and an electric forehead-light are required. Long strips of gauze must be ready for packing in case of hemorrhage. The patient is placed recumbent, with head turned to the opposite side. The application of a provisional ligature or clamp to the external carotid artery is advocated by some, but this step will not control the venous bleeding, which is the most harassing hemorrhage encountered. A large osteoplastic flap is formed in front of the ear (Fig. 385), and is broken out. Hemorrhage is arrested. It may be found that the meningeal artery has been ruptured. If this accident has happened and the vessel lies in a bony canal, plug with Horsley's wax. If the vessel is bleeding upon the dura, ligate by passing suture-ligatures around it. If it is torn off at the foramen spinosum, pack the foramen with iodoform gauze, and postpone the conclusion of the operation for forty-eight hours. It may be necessary, at any stage of this formidable operation, to pack the wound and postpone completion for two days. Some surgeons (Krause, Bergmann) ligate the meningeal artery as a routine procedure; but this operation is often difficult and requires much time. If the unligated vessel is divided, the hemorrhage can be arrested by gauze packing or by plugging the foramen spinosum. The head and body of the patient should now be elevated. This allows the brain to drop posteriorly and renders forcible retrac-

tion unnecessary, and, further, it lessens venous bleeding (Lexer). The next step is to lift up the dura and with it the brain (Fig. 386). Find the inferior maxillary nerve and clamp it with hemostatic forceps. Find the superior maxillary nerve and clamp it. Loosen the nerves from their beds with a dry dissector and divide each one at its foramen of exit. Twist the clamp-forceps so as to reel up the nerves. This pulls out the ganglion intact with the motor root and the root of origin, as far back as the pons (Krause's method). Arrest bleeding; close the flap; sew the lids of the affected side together and cover the eye with a watch-crystal.

Cushing has modified the Hartley operation so as to permit of extradural manipulation below the arch made by the middle meningeal artery and thus lessen the danger of laceration of the artery ("Jour. Amer. Med. Assoc.," April 28, 1900). He trephines the wall of the temporal fossa very low down, opens into the skull below the arch of the meningeal vessels, and thus avoids the meningeal at the foramen spinosum of the sphenoid bone and the sulcus arteriosus of the parietal bone.

Horsley's Intradural Method.—An opening is made into the middle fossa of the skull, the dura is opened, and the ganglion is found and removed. This operation is easier than the extradural method, but is believed to be more dangerous.

The Frazier-Spiller Operation of Intracranial Neurotomy of the Sensory Root of the Trigeminus.—If experience shows that after division of the sensory root the nerve does not regenerate, and it seems probable that it does not, the operation must be regarded as a valuable addition to our resources. In this operation the zygoma is temporarily resected. The temporal fossa is exposed, the bony wall is trephined, and the trephine opening is enlarged by the use of a rongeur. The dura is separated and the ganglion and its sensory root exposed. The dural envelope of the ganglion is opened, is separated, and the sensory root is exposed. The sensory root is then picked up on a blunt hook and divided. It is frequently possible, Frazier tells us, to separate the sensory root from the motor root.

Abbe's Operation of Intracranial Neurectomy.—Ligate the external carotid artery of the diseased side, make a vertical incision over the middle of the zygoma down to the bone. An opening into the skull is made by a mallet and gouge, and this opening is enlarged by a rongeur until it is one and one-half inches in diameter. The dura is lifted from the middle fossa and the nerves are exposed. Each nerve-trunk is clamped, is divided near its foramen of exit, and is separated from the ganglion by cutting or by twisting with the forceps. A strip of sterile rubber tissue, one and one-half inches in length and three-fourths of an inch in width, is laid over the round foramen and the oval foramen and is pressed into place by gauze. In a few moments the gauze is withdrawn and the ganglion is allowed to descend upon the rubber tissue. The wound is then closed. (See Robt. Abbe, in "Annals of Surgery," Jan., 1903.) The rubber tissue is used to block the foramina of exit and prevent future emergence of regenerating nerves.

Operation for Facial Paralysis of Extracerebral Origin (Facio-accessory Anastomosis and Faciohypoglossal Anastomosis).—Operation for this condition was first performed in 1895. (See "Remarks on the Operative Treatment of Facial Palsy of Peripheral Origin," by Chas. A.

Ballance, Hamilton A. Ballance, and Purves Stewart, "Brit. Med. Jour.," May 2, 1903; and also the "Surgical Treatment of Facial Paralysis by Nerve Anastomosis," by Harvey Cushing, "Annals of Surgery," May, 1903.) In 1898 Furet suggested to Faure that he should anastomose the peripheral end of a divided facial nerve to that portion of the spinal accessory nerve which goes to the trapezius muscle. Faure did this, but the operation failed. Robert Kennedy, of Glasgow, did the first successful operation. He divided the facial for the relief of spasm and at once anastomosed a partially divided spinal accessory. The procedure first employed by Ballance was, after noting by galvanism that muscular fiber still remained, to expose the facial nerve at its point of exit from the stylomastoid foramen, to cut the nerve-trunk across as high up as possible, to expose the spinal accessory, and to suture the distal end of the facial into the trunk of the spinal accessory. The spinal accessory was cut half through to make a bed for the end of the facial. The paper of the Ballances and Stewart above referred to recommends end-to-side anastomosis between the divided facial and the hypoglossal. The authors have operated five times for facial palsy, and Cushing, Keen, Hackenbruch, and Körte have done similar operations. The conclusions of the Ballances and Stewart are as follows ("Brit. Med. Jour.," May 2, 1903):

"1. Peripheral facial palsy is remediable by facio-accessory anastomosis, but the extent of recovery appears to be limited to associated movements in conjunction with the shoulder. In most cases the previous deformity disappears when the face is at rest.

"2. For reasons above stated we would in future recommend facio-hypoglossal anastomosis rather than facio-accessory.

"3. The cases most suitable for operation are those in which the paralysis has lasted so long that no recovery is to be expected—say, facial palsy lasting six months without any sign of recovery. In our opinion the sooner the operation is done after this date, the better.

"4. A suppurative causal condition producing an infective neuritis renders the prognosis after operative treatment less favorable than in cases due to trauma."

Operation for Brachial Birth Palsy.—(See article by L. P. Clark, A. S. Taylor, and T. P. Prout, in "Am. Jour. Med. Sciences," Oct., 1905.) These authors report 8 cases of operation with some notable improvements and with 2 deaths. In these cases they found great thickening of the fascia and in some cases fibrous tissue almost completely obscured the remains of lacerated trunks or roots. They advise that the patient be placed recumbent, with a sand-pillow beneath the shoulders and with the head extended and bent toward the opposite shoulder. An incision is made at the posterior border of the sterno-cleidomastoid and the plexus is exposed and explored. If the lesion is above the clavicle, it is at once attacked; if below that bone, the incision is carried down, and the bone is sawed in two. The scar tissue with the lacerated nerves is removed and the nerves or nerve-roots are sutured. The wound is closed, the clavicle being wired if it was divided. After dressings are applied the head is bent toward the shoulder of the damaged side and fixed with plaster-of-Paris.

I operated on a case of Dr. Charles S. Potts's in the Phila. Hospital. The roots were not torn, but were found imbedded in a thin layer of scar which it was possible to remove. The result was good.

XXIII. DISEASES AND INJURIES OF THE HEAD.

Diseases of the Head.

In approaching a case of brain disorder, first endeavor to locate the seat of the trouble; next, ascertain the nature of the lesion; and, finally, determine the best plan of treatment, operative or otherwise. In all operations upon the brain the surgeon must be able to determine accurately the situations of certain fissures and convolutions, the finding of the situations of these convolutions and fissures comprising the science of *craniocerebral topography*.

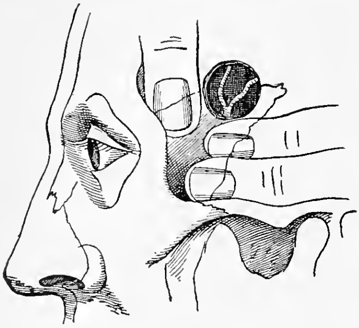


Fig. 387.—The meningeal artery exposed by trephining (after Esmarch).

The regional terms used in craniocerebral topography are derived from Broca (Fig. 388). The middle meningeal artery is found at the *pterion*, one and one-quarter inches posterior to the external angular process, on a level with the roof of the orbit (Fig. 387). The fissures and convolutions of the brain are shown in Figs. 389–391. The *fissure of Bichat* is marked by a line on each side drawn from the *inion* to the external auditory process. A line from the *glabella* to the inion overlies the median fissure and the superior longitudinal sinus. The *fissure of Rolando* is very important, as marking the posterior limit of the motor region of the brain. It begins near the median line, half an inch posterior to the middle of the distance between the inion and glabella (Thane). This fissure runs downward and forward at an angle of 67.5°

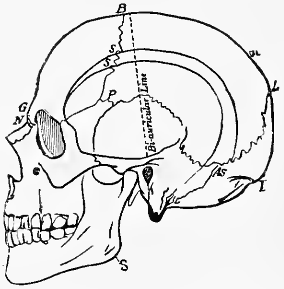


Fig. 388.—Skull, showing the points named by Broca: *As*, Asterion (junction of the occipital, parietal, and temporal bones); basion, middle of anterior wall of foramen magnum; *B*, bregma (junction of the sagittal and coronal sutures); *G*, ophryon (on a level with the superior border of the eyebrows, and corresponding nearly to the glabella, the smooth swelling between the eyebrows); *g*, gonion (angle of the lower jaw); *I*, inion (external occipital protuberance); *L*, lambda (junction of sagittal and lambdoidal sutures); *N*, nasion (junction of the nasal and frontal); *Ob*, obelion (the sagittal between the parietal foramina); *P*, pterion (point of junction of great wing of sphenoid and the frontal, parietal, and squamous bones. This may be **H**-shaped or **K**-shaped or "retourné," in which the frontal and temporal just touch); *S*, stephanion (or, better, the superior stephanion, intersection of ridge for temporal fascia and coronal suture); *S′*, inferior stephanion (intersection of ridge for temporal muscle and coronal suture).

for a distance of three and three-eighth inches. Chiene finds the fissure of Rolando by the following method: He takes a square piece of paper and folds it into a triangle (Fig. 393, 1); the angle B A C of this triangle is 45°; the edge D A is folded back on the dotted line A E; the angle D A E equals half of 45°, or 22.5°, and the angle C A E equals the same (Fig. 393, 2); unfold the paper in the line C A; in the figure thus formed B A C = 45° and E A C = 22.5°; E A B = 67.5°, which is the angle desired. Place the point A in the mid-line of the head, over the point of origin of the Rolandic fissure; the side A B is laid along the middle line of the head, and the line A E corresponds to the fissure of Rolando.* Fig. 392 shows Chiene's scheme for locating various points upon the brain. Horsley determines the situation of the Rolandic fissure by the use of his metal cyrtometer (Fig. 394). He places the point marked zero over the inioglabellar line and midway between the inion and the glabella. To find the *fissure of Sylvius* (Fig. 390, *S*, *s′*, *s″*), draw a line from the external angular process to the occipital protuberance. The fissure of Sylvius begins on this line one and one-eighth inches behind the external angular process; the main branch of the fissure runs toward the parietal eminence; the ascending branch of the fissure corresponds to the squamososphenoidal suture, and continues upward in the same line half an inch above the suture. The *precentral sulcus* (Fig. 390, F) limits anteriorly the ascending frontal convolution; it runs parallel with and just behind the coronal suture, and a finger's breadth in front of the fissure of Rolando. The *intraparietal fissure* (Figs. 389, 390, *ip*) limits the ascending parietal convolution posteriorly. It begins opposite the junction of the lower and middle thirds of the fissure of Rolando, passes

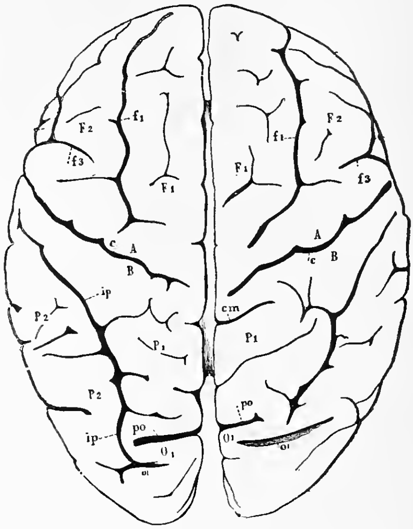


Fig. 389.—View of the brain from above (Ecker).

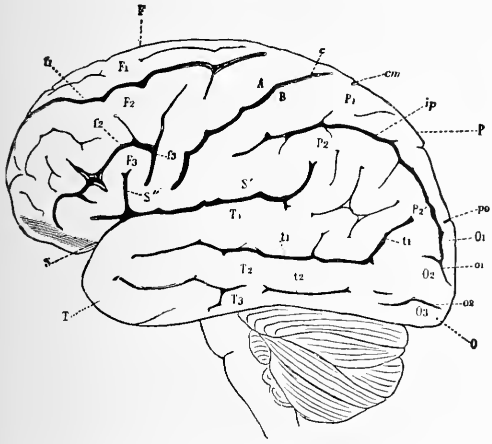


Fig. 390.—Outer surface of the left hemisphere of the brain (Ecker).

* "American Text-book of Surgery."

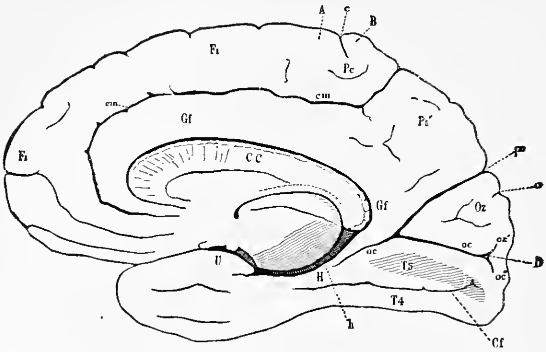


Fig. 391.—Inner surface of the right hemisphere of the brain (Ecker).

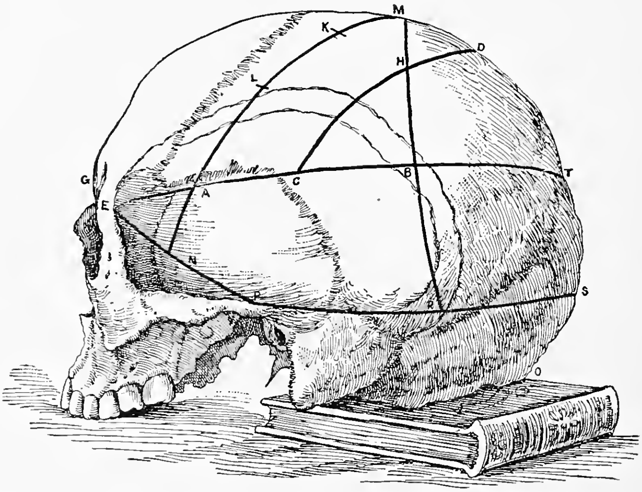


Fig. 392.—Chiene's lines for localizing brain-areas: M D C A, Rolandic or motor area; A, anterior branch of middle meningeal and bifurcation of fissure of Sylvius; A C, horizontal part of Sylvian fissure; the highest part of the lateral sinus touches P S at R; M A, precentral sulcus; I, beginning of superior frontal sulcus, M B C, contains the supramarginal convolution; B, angular gyrus.

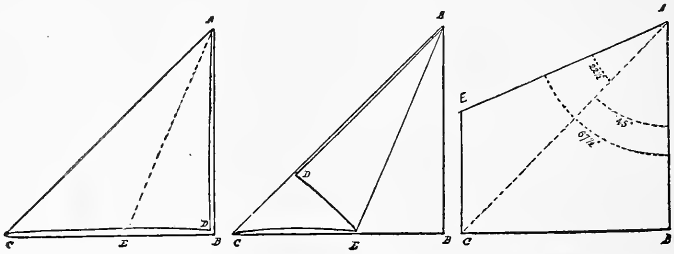


Fig. 393.—Chiene's method of fixing position of Rolandic fissure ("American Text-book of Surgery").

upward in a line parallel with the longitudinal fissure and midway between the Rolandic fissure and the parietal eminence, passes by the parieto-occipital fissure, and downward and backward into the occipital lobe. The motor areas, which on

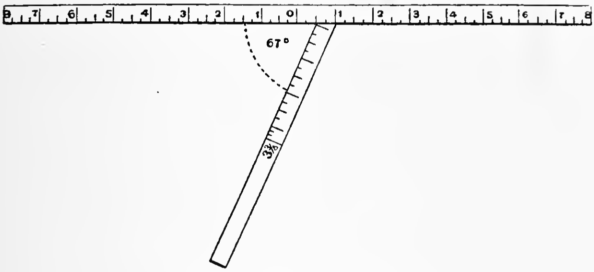


Fig. 394.—Horsley's cyrtometer.

the outer surface are adjacent to the fissure of Rolando, are shown in Figs. 389 and 390.* The superior longitudinal sinus is overlaid by a line from the inion to the glabella. The lateral sinus is indicated by a line running from the occipital protuberance horizontally outward to a point one inch posteriorly to the external auditory meatus, and from this point by a second line dropped to the mastoid process. The *supra-meatal triangle* of Macewen is bounded by the posterior root of the zygoma, the posterior bony wall of the auditory meatus, and a line joining the two. The mastoid antrum is opened through *Macewen's triangle* to avoid injury to the lateral sinus. *Barker's point*, the proper spot to apply the trephine in abscess of the temporo-sphenoidal lobe, is one and one-fourth inches above and one and one-fourth inches behind the middle of the external auditory meatus. Fig. 395 shows clearly the main points of craniocerebral topography, obtained by methods approved by many scientists.

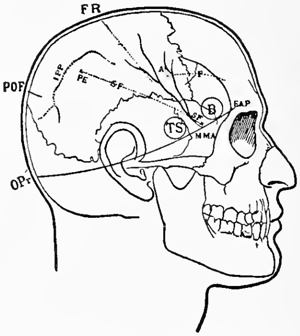


Fig. 395.—Head, skull, and cerebral fissures; B Corresponds to Broca's convolution; EAP, external angular process; FR, fissure of Rolando; IF, inferior frontal sulcus; IPF, intraparietal sulcus; MMA, middle meningeal artery; OPr, occipital protuberance; PE, parietal eminence; POF, parieto-occipital fissure; SF, Sylvian fissure; A, its ascending limb; TS, tip of temporo-sphenoidal lobe. The pterion (to the left of B) is the region where three sutures meet, viz., those bounding the great wing of the sphenoid where it joins the frontal, parietal, and temporal bones (adapted from Marshall by Hare).

Krönlein's method of localizing certain points is the most generally serviceable. (See Fig. 396.) A line, known as the base line, Z M, is carried horizontally backward from the lower border of the orbit through the upper border of the external auditory meatus. Another horizontal line, K K′, is drawn parallel with this, on a level with the supra-orbital ridge. A line Z K is erected from the middle of the zygoma to the supra-orbital line. A vertical line is drawn from the articulation of the lower jaw, A, and is prolonged to R. A vertical line is

* Recent studies indicate that the motor region is entirely in front of the Rolandic fissure.

drawn from the posterior border of the mastoid base (M K′) and is taken to P, the middle line of the skull. A line is drawn from K to P, and between the points R and P′ it overlies the fissure of Rolando. The angle of P K K′ is bisected by the line K S, which corresponds to the fissure of Sylvius from its point of bifurcation to its posterior termination. K marks the bifurcation of the fissure of Sylvius. To reach the anterior branch of the middle meningeal artery trephine at K; to reach the posterior branch, trephine at K′.

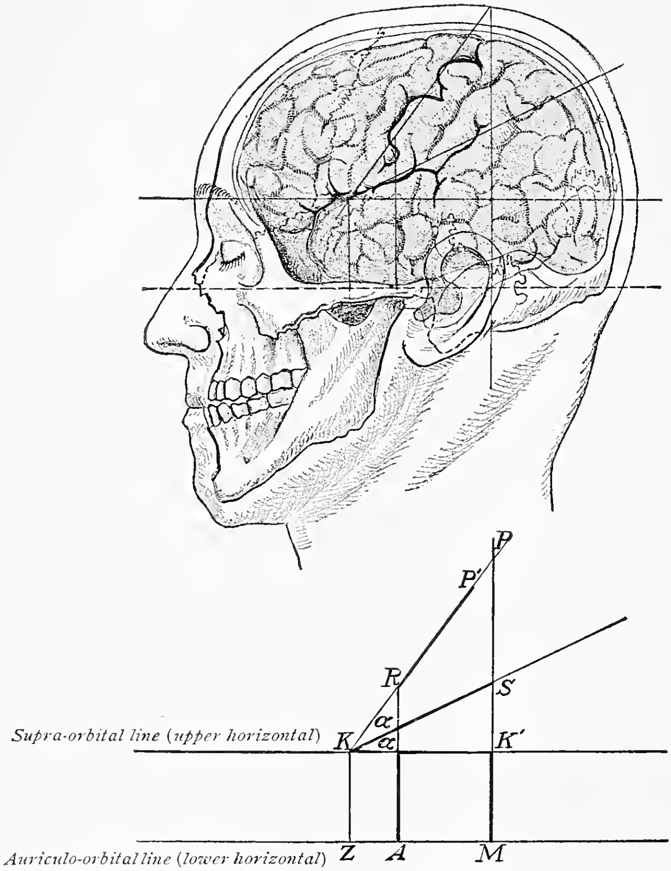


Fig. 396.—Krönlein's method of locating the fissures of Rolando (*RP′*) and Sylvius (*KS*); Krönlein's point of trephining for hemorrhage from the middle meningeal (*KK′*); and von Bergmann's region for trephining for abscess of the temporo-sphenoidal lobes (*AaK′M*) ("American Text-book of Surgery").

Head Injuries During Labor.—Caput Succedaneum.—This condition is edema of the scalp due to prolonged pressure. The edema is circumscribed and occupies the part not subjected to pressure. The parts subjected to pressure may appear normal or may exhibit ecchymoses or even excoriations. The pressure is usually made by the os, and because the most frequent presentation is left occipito-anterior, the common position of the caput is over the superior and posterior portion of the right parietal bone. The edematous

swelling results from congested veins, it contains bloody serum, and the skin above it is usually discolored by ecchymosis. No treatment is necessary, as the condition will disappear in from a few hours to three days.

Cephalhematomata.—By this term we mean extravasations of blood beneath the pericranium due in most cases to the same pressure which causes caput succedaneum, but in some cases to bending or breaking of a cranial bone. The condition is said to occur in 1 labor out of 200. In most cases there is but 1 cephalhematoma, but there may be 2, 3, or even 4. The commonest situation is over the right parietal bone (the common seat of caput succedaneum) and caput succedaneum is frequently associated with a cephalhematoma. The blood begins to flow out during labor and the swelling increases during the first few days after birth; in fact, it is frequently not noticed for a day or two. The swelling is tense and smooth with a convex outline. It may cover but a small portion of the bone or the entire bone, but never extends beyond the bounding sutures. This limitation is due to the fact that the pericranium is adherent to the sutures. In the course of a couple of weeks the tumor may become surrounded by a hard ring due to the formation of new bone, and a shell of bone may eventually surround and cover over the clot, an area of permanent bony thickening remaining. In other cases no bone forms, but the clot gradually disappears.

Cephalhematomata do not require incision—they usually disappear. If suppuration occurs, incision is necessary. Suppuration may occur if the scalp was excoriated.

Diseases of the Scalp.—The scalp is composed of skin, subcutaneous fat, and the occipitofrontalis muscle and aponeurosis. The scalp is liable to inflammation from various causes, and also to other diseases—namely, tumors, cysts, warts, moles (local cutaneous hypertrophies), cirsoid aneurysm (page 373), nevi, and lupus. *Abscesses of the scalp* are common. If an abscess forms beneath the pericranium, the pus diffuses over the area of one bone, being limited by the attachment of the pericranium in the sutures. If an abscess forms in the tissue between the occipitofrontalis and the pericranium, it is widely diffused. Treves calls this subaponeurotic connective tissue "the *dangerous area.*" Abscess of the subcutaneous tissue is apt to be limited because of the great amount of fibrous tissue. Abscess is treated by instant incision at the most dependent part, and drainage.

Diseases and Malformations of the Bones of the Skull.—The bones of the skull are liable to caries, necrosis, osteitis, periostitis, atrophy, hypertrophy, tumors, etc. (see Diseases of Bones).

Cranial Pneumatocele.—This rare condition is a result of perforation of a bone which permits air to collect beneath the periosteum. It may occur in the mastoid or occipital region or over the frontal region. These protrusions vary greatly in size; and as their shape depends upon the periosteal attachment to sutures in the neighborhood, they vary in shape. The overlying tissues are natural in appearance. The protrusion is tense, but may lessen or disappear on pressure. McArthur points out ("Jour. Am. Med. Assoc.," May 6, 1905) that if diminished by pressure, the patient may hear a sound like rushing air or water in the ear if the protrusion is occipital or mastoid; and in the nose, if it is frontal. An elevated ridge of bone surrounds a pneumatocele. The protrusion is tympanitic on percussion. The

condition is due to perforation of the bony wall of an air sinus by disease or injury or rupture. McArthur points out that in half of the reported cases the rupture was not preceded by any history of inflammation or injury. The condition is not dangerous.

Treatment.—Incision, finding the opening, enlarging it, removing osteophytes; bringing the walls of the cavity together and applying pressure.

Microcephalus.—By microcephalus is meant unnatural smallness of the head due to imperfect development. Marked microcephalus is not a common condition, but it is an occasional cause or associate of idiocy. A child may be born with a skull completely ossified even at the fontanelles, or the ossification may become complete soon after birth, but in many cases of microcephalus ossification takes place late or not at all. In microcephalus the face is usually fairly well developed; the jaws are prominent; the forehead is flat; the cranium and brain are small; the convolutions of the brain are simpler than is natural; there is apt to be marked asymmetry of the two sides of the brain; internal hydrocephalus may exist; areas of sclerosis and atrophy are common; porencephaly is not unusual. Some patients have perfect motor power; others are slow and incoördinate. Epilepsy, chorea, and athetosis frequently complicate the case. Idiots of this type often present deformities such as cleft palate, strabismus, distorted ears, hypertrophied tongue, deformed genitals or extremities, ill-shaped and irregularly developed teeth. They exhibit irregular muscular movements, are frequently paralyzed in childhood (infantile paraplegia or hemiplegia), and suffer from subsequent contractures. They are active, destructive, excitable, and are liable to be violent and almost demoniacal. As Clouston says, they look impish and unearthly.

Treatment.—Skilled training in a school for the feeble-minded or in an institution for idiots is necessary in treating microcephalic idiocy. Idiots have but little power of attention, and sensory impressions give rise to but few concepts, and these are feeble and fleeting. In order to educate the idiot it is highly desirable that speech be acquired, and "the more strongly the attention can be aroused, the more perfect does speech become" (Kirchhoff). The principle of the education of idiots is to stimulate, coördinate, and guide sight, hearing, and feeling.

Lannelongue, of Paris, has suggested an operation in cases of idiocy with premature ossification (see Linear Craniotomy, page 740). In this procedure the author has no confidence. Idiocy is a general disorder and not a local brain disease. Soft parts mould bone, and bone does not control soft parts. There is no evidence that the brain is being compressed; in fact, the simplicity of the convolutions suggests the contrary. In many typical cases of microcephalic idiocy there is no synostosis even years after birth. The operation has been much abused. It is sometimes fatal, and, although a fatality may gratify the family, a surgeon is not a legal executioner. The remarkable improvement which has been reported in some cases is wrongly supposed to be due to the operation. As a matter of fact, the new surroundings, the strange faces, the firm discipline, the effect of the anesthetic, and the shock of the operation attract the feeble attention and rouse the sluggish senses. Many cases are brought for operation because they are for the time being unusually intractable and excitable, and the return to the usual level of

conduct after operation is regarded as a permanent gain, when it is often but a temporary alleviation. We believe that scientific training is the proper treatment, and that the efficiency of training is not increased by the previous performance of craniotomy, and we follow the precept of Agnew, that a surgeon might as well cut a piece out of a turtle's back to make a turtle grow as to cut a piece out of the skull to make the brain grow.

Diseases and Malformations Involving the Brain.—Cephaloceles.—A cephalocele is a congenital protrusion of intracerebral contents through a defect in the skull. These protrusions are covered with skin. The defect through which the protrusion occurs is always in the median line, although in some cases (as at inner angle of the orbit) the visible protrusion may be at the side. Nearly all such protrusions are either frontal or occipital, although now and then one presents in the pharynx, having emerged from the skull between the body of the sphenoid and the ethmoid.

Frontal cephaloceles are divided into:

1. Nasofrontal—those which are in the region of the glabella.
2. Naso-orbital—those at the inner angle of the orbit.
3. Nasoethmoidal—those below a nasal bone.

Each one of the above forms passes through the horizontal plate of the ethmoid.

Occipital cephaloceles are divided into:

1. Superior—those above the external occipital protuberance. In these the bony gap may join the posterior fontanel.
2. Inferior—those below the external occipital protuberance. In these the bony gap may join the foramen magnum.

The above regional classification is that advocated in von Bergmann's "System of Practical Surgery" (translated and edited by Wm. T. Bull and Walton Martin).

The commonest form is hydrencephalocele, and all other forms result from retrograde changes in this.

Hydrencephalocele.—This is by far the commonest and is also the most dangerous form encountered. The protrusion consists of arachnoid, a layer of brain tissue, and a cavity containing ventricular cerebrospinal fluid and connected with the lateral ventricle. It is in reality a protrusion of the lateral ventricle. It is covered with skin—natural skin, unless the protrusion is very large, in which case the skin is more or less atrophied. Beneath the skin is fascia and beneath this, arachnoid. The pericranium and dura do not cover it, but each has a gap in it and these two tissues join each other around the bone margins.

Encephalocele.—Results from retrograde changes in a hydrencephalocele. The protrusion of the ventricle has become reduced and the hernia consists of a portion of brain covered by arachnoid. Encephalocele is only seen in the nasofrontal region. If there is any fluid in this protrusion, it is not in its interior, but on its surface, and results from a cyst of the arachnoid.

Meningocele.—We formerly understood by a meningocele a protrusion of the membranes alone; we now regard it as a condition resulting from retrograde changes in a hydrencephalocele. The brain tissue of the latter disappears; beneath the arachnoid is a layer of cells identical with those which line the ventricles; the connection with the ventricle is entirely or almost

completely cut off; a cyst forms in the subarachnoid tissue, and thickened pia surrounds the cyst. (See "System of Practical Surgery," by E. von Bergmann, vol. i, translated and edited by Wm. T. Bull and Walton Martin.) The above condition is called by von Bergmann encephalocysto-meningocele.

Diagnosis.—The congenital origin and situation make certain that the condition is cephalocele. The bony gap can usually be felt; whether it can or cannot, an *x*-ray picture should be taken. Such a picture may indicate that the mass contains brain matter. The protrusions vary greatly in size and shape. Some are rounded, some are flattened, some are stalked. The skin covering them may be natural, atrophied, filled with vessels, scarred, or ulcerated. Sometimes the cephalocele is very tense; sometimes it is loose. In naturally hairy regions the skin over the summit of the protrusion is bald, but that around the base is hairy. If there is connection between the interior of the protrusion and the ventricle, the mass can be diminished in size by compression. If it shrinks rapidly from compression, the opening into the ventricle is large. In such cases compression of the mass quickly causes signs of cerebral pressure. Lumbar puncture may cause the protrusion to diminish in size; crying may cause it to increase in size. Large cephaloceles fluctuate and perhaps pulsate. Meningocele feels and looks like a cyst (is translucent and fluctuates); it does not usually pulsate, it has a small base, it becomes tense on forcible expiration, and some cases can be very slowly diminished by compression.

Encephalocele is small, opaque, does not fluctuate, has a broad base, does pulsate, becomes tense on forced expiration, and attempts at reduction fail and cause pressure symptoms.

Hydrencephalocele is larger than a meningocele, is translucent, fluctuates, rarely pulsates, is pedunculated, is rendered a little tense on forced expiration, and can be lessened in size by compression but cannot be reduced.

Treatment.—In von Bergmann's "System of Practical Surgery" we find the wise caution to attempt no operation for an occipital protrusion beneath the protuberance, when the cleft enters the foramen magnum and is associated with cleft of the cervical vertebræ—for a condition in which the soft parts are defective and the brain is exposed (*cranioschisis*)—on a case complicated with hydrocephalus or on a case complicated by some other condition which is of necessity fatal. We no longer refuse to operate because the mass contains some brain matter or because it communicates with the ventricle, although if it does so, the prognosis is much worse. For a large hydrencephalocele nothing can be done and early death is inevitable. In rare instances an encephalocele is converted into a meningocele, and the bony aperture closes, thus bringing about a cure. Among the expedients for treating meningocele are electrolysis, injection of Morton's fluid (gr. x of iodin, gr. xxx of iodid of potassium, ℥j of glycerin), pressure, and excision. In cases of cephalocele, when portions of the nerve-centers are not contained in the sac, A. W. Mayo Robson advises the performance of a plastic operation. He ligates the neck of the sac, excises the sac, sutures the skin-flaps separately, and leaves the stump outside the line of superficial sutures. It is usually possible to tell by palpation if nerve-centers are in the sac, but if in doubt, make an exploratory incision, and sweep the finger around inside of the sac.* Meningoceles should be operated upon by Robson's plan.

* "Amer. Jour. Med. Sciences," Sept., 1895.

Spurious Meningocele (*The Puffy Tumor of Pott*).—It occasionally happens, after a fracture of a child's skull, that cerebrospinal fluid gathers beneath the pericranium and bulges the pericranium and scalp. When a spurious meningocele forms, the bone must have been broken and the dura and arachnoid ruptured. This protrusion fluctuates, pulsates, and is influenced by respiration. In some cases there is communication with the ventricles of the brain. The parietal and frontal regions are the most usual seats of the trouble. The opening in the skull may close; it may remain stationary; it may actually enlarge by bone-absorption. In some cases the spurious meningocele undergoes spontaneous cure; in some cases rupture occurs; in other cases death takes place as a result of the cerebral injury. (See Joseph Sailer on "Spurious Meningocele," "University Med. Magazine," Sept., 1900.)

Treatment.—Close the opening by a plastic operation.

Hydrocephalus.—In *external* hydrocephalus the fluid is in the cerebral membranes; in *internal* hydrocephalus the fluid is in the ventricles. Hydrocephalus may be *acute* or *chronic*, *congenital* or *acquired*.

Acute hydrocephalus is usually internal, but may be external. It results from meningitis—usually tuberculous meningitis of the base. The symptoms are headache, elevated temperature, delirium, stupor, convulsions, paralysis, and choked disc.

Treatment of acute hydrocephalus by medical means is of no avail. Tapping of the ventricles may be tried.

Chronic internal hydrocephalus is usually congenital, but may arise after birth in children under seven. In congenital hydrocephalus the condition may be due to circulatory disturbances in the brain of the embryo resulting from uterine disease or injury during pregnancy. Syphilis and alcoholism in parents seem sometimes to be responsible. Chronic acquired hydrocephalus results from inflammation, especially tuberculous inflammation. A tumor pressing on the veins of Galen may cause it. In chronic acquired internal hydrocephalus there is overproduction or underabsorption of cerebrospinal fluid and perhaps both conditions may exist. The usually causative condition is an inflammation of the interior of the ventricles, particularly of the choroid plexuses, and as a consequence venous return is obstructed and oversecretion occurs. One or both foramina of Monro may be closed, and if only one is closed, unilateral hydrocephalus may arise (Alfred S. Taylor, in "Am. Jour. of Med. Sciences," August, 1904). The aqueduct of Sylvius, the foramen of Magendie, and the central canal of the cord may be occluded. The cranium enlarges enormously and the bones of the skull are widely separated. The brain is distended and thinned and the sulci are obliterated. The broad forehead overhangs the eyes; the fontanelles are elevated. The child is mentally weak or is an idiot, and very often does not learn to walk or to talk. Convulsions, palsies, and contractures are common, and blindness is frequent. Such children usually die young.

The *treatment* of chronic hydrocephalus is rarely of much avail. Pressure by strapping with adhesive plaster has been tried. Tappings through a fontanelle may be performed by means of a trocar (only ℥ij or ℥iij of fluid being withdrawn at a time). If much fluid is allowed to flow out, the head must be

strapped with adhesive plaster afterward. If the skull ossifies, the lateral ventricles may be tapped after trephining. It has been proposed to drain by tapping the theca of the spinal cord (Quincke). This last operation is called *lumbar puncture* (pp. 763, 764). It will, of course, fail if the foramina in the floor of the fourth ventricle or the aqueduct of Sylvius are blocked. Even if they are open, it is of little service. The operation which promises most was devised by Sutherland and Cheyne, and is known as *intracranial drainage* ("Brit. Med. Jour.," Oct. 15, 1898). Their theory is that in hydrocephalus fluid distends the ventricles because the channels of communication between the ventricles and the subarachnoid spaces are closed. The subarachnoid spaces communicate directly with veins, hence fluid cannot collect under pressure in these spaces. Intracerebral drainage establishes a communication between the subarachnoid space and one ventricle. It is not necessary to operate on both sides in bilateral hydrocephalus, because the lateral ventricles communicate. A small opening is made in the skull. The dura is incised. A number of strands of catgut, which are tied together, are pushed through the brain so that one end of the catgut mass lies in a ventricle and the other end beneath the dura. The dura and scalp are then sutured. Brewer makes an osteoplastic occipital flap, makes a dural flap, lifts the cerebral lobe, and pushes a drain of rubber tissue into a lateral ventricle.

The elder Senn passed a rubber tube into the ventricle and put the outer end of the tube beneath the skin of the scalp.

Alfred S. Taylor ("Am. Jour. Med. Sciences," August, 1904) makes an osteoplastic flap with its base over the right mastoid, cuts a dural flap, passes a slender aspirating needle through the second temporo-sphenoidal convolution into the lateral ventricle, draws off a *little* fluid, and measures the thickness of the brain. He then takes 6 strands of No. 2 forty-day catgut, each strand half an inch longer than the thickness of the brain. The strands are tied together with a spiral of catgut, $1\frac{1}{4}$ inches of the loop being left free. Three layers of Cargile membrane are wrapped about the shaft, but the tip remains free. It is carried into the ventricle along the needle track by thumb forceps, and the loops are slipped here and there, but chiefly downward, under the dura. Cargile membrane is placed between the loops and dura and the dura and skin are sutured. Taylor operated on 6 cases and 2 recovered, with relief of all signs of pressure.

Injuries of the Head.

Caput Succedaneum.—(See page 690.)

Scalp-wounds.—Scalp-wounds bleed profusely because the scalp is very vascular, because many of the blood-vessels are in fibrous tissue and cannot contract and retract, and because even blunt force splits the scalp almost like an incision. Scalp-wounds are treated as are other wounds. Even a large piece of scalp with only a narrow pedicle may not slough; hence try to save any piece that has an attachment. Always shave a wide area and disinfect the shaven area and the wound. Arrest hemorrhage, and exercise great care in cleansing the wound and the parts about it. Stitch the wound with silkworm-gut. Very few sutures are needed if the wound is longitudinal, but many are required if it is transverse. The permanent arrest of hemorrhage is rarely effected by ligatures, but rather by sutures judiciously placed. If drainage is required, use a few strands of silkworm-gut; but drain-

age is rarely used unless we know the wound is grossly infected. Wet antiseptic dressings are used for the first few days and moderate pressure is applied by wet gauze bandages. Avulsion of the scalp is discussed on page 251.

Contusions of the Head.—Scalp-swelling from hemorrhage is usually considerable. The patient may be stunned or dazed. The swelling of hematoma must not be mistaken for *fracture* with depression. In hematoma there is a central depression; hard pressure on the center finds bone on a level with the general contour of the bone, and the margin of a hematoma is circular, is not quite hard, and is elevated above the general contour. In depressed fracture the edge is on a level with or below the level of the general bony contour, and the margin is sharp and irregular. The **treatment** is by bandage-pressure. If suppuration arises, at once incise.

Concussion, Contusion, and Laceration of the Brain.—For many years it was customary to regard concussion as a condition produced by molecular vibrations in the nervous substance of the brain. Duret's classical observations profoundly modified surgical thought, and led to the opinion that in concussion of the brain there is injury to the brain itself, a rupture of cerebral vessels brought about by the advance and recession of a wave of cerebrospinal fluid. This wave, it is thought, first flows in the direction of the force. Keen says that there may be slight brain injuries which can properly be called "concussions," but it is better to consider concussion as synonymous with laceration of the brain. Kocher considers concussion as identical with *contusion of the brain.* It seems, however, highly improbable that slight cases of concussion are accompanied by vascular rupture or organic mischief; the symptoms are too transitory, and reaction too rapid and complete to permit of any such view. Experiments on animals show we can develop concussion without laceration or contusion. Autopsies have been carefully made in some cases of death from concussion, and no organic lesion has been discovered. It is quite true that the same force which causes the concussion may cause contusion or multiple lacerations, and a severe force is apt to do so. But we are not then justified in assuming that concussion is contusion or laceration: we should rather conclude that the individual had both concussion and a demonstrable injury. Both conditions arise from violence, but the two conditions are not identical. I believe with von Bergmann that there is such a condition as concussion, which may be pure concussion or may be associated with organic damage, and even if a man dies and is found to have an organic injury, the concussion may have caused, or, at least, have hastened, the fatal result. I believe with von Bergmann that it is not repeated waves of force from the blow but the concussion of the blow itself that does the harm. The brain is momentarily displaced by the blow. The blow acts on the entire brain; the centers are first stimulated and then depressed, and in fatal cases are not only depressed but are paralyzed. The cause of concussion is violent force either direct (as a blow upon the head) or indirect (as a fall upon the buttocks). This force shakes, oscillates, jars, or displaces the brain, giving rise to stimulation and then to exhaustion of the nerve-centers, and perhaps to rupture of vascular twigs, large vessels, or even the membranes. In the less severe cases concussion only exists; in the more severe cases there is also contusion or laceration or compression soon arises.

As von Bergmann points out, the entire cortex in concussion is momentarily

stimulated and then depressed. The momentary stimulation exists when a man "sees stars" as a result of a blow. The depression or exhaustion is manifested by heaviness, dulness, stupor, perhaps by unconsciousness. The stimulation of the medullary centers, von Bergmann points out, lasts longer, as a rule, than the stimulation of the cortex, and is manifested particularly by a slow pulse. If the pulse grows rapid and weaker, the pneumogastric center is becoming exhausted and the patient is in danger of death. In slight cases of concussion only the cortex may be involved, the medullary center escaping. In rapidly fatal cases of concussion the medullary centers are quickly paralyzed.

Symptoms.—In very trivial cases the patient is slightly and momentarily dazed and the pulse is temporarily slow and weak, but he is otherwise unaffected. In a rather slight case of brain concussion the patient may or may not fall; his face is pale; he feels weak, giddy, nauseated, and confused; but he soon reacts, and often vomits. The pulse is weak and is slow for a time and then becomes normal. In a severe case he lies in a state of complete muscular relaxation. The extremities are cold; the skin is pale and cold; the pulse is small, soft, slow, and weak, because of stimulation of the pneumogastric center; the respiration varies, being sometimes deep, sometimes superficial, sometimes rapid, and sometimes irregular. He seems unconscious, but can usually be roused to monosyllabic response by shouting, pinching, or holding a bright light near his face. Occasionally, however, there is complete unconsciousness. The urine and feces are often passed involuntarily. The pupils may be unaltered, may be dilated or contracted, may be equal or unequal, but in any case they will react to light. Paralysis rarely exists, but if there is paralysis, it is temporary. The temperature at first is subnormal. In a very severe concussion in which there is great danger of death the pulse is very rapid, small, weak, and probably irregular because of exhaustion of the medullary center, and the patient is absolutely unconscious because of depression of the cortex. In a severe cortical laceration there will be twitchings or even general convulsions, or the patient will lie curled up with limbs flexed and eyelids shut, and will resist all attempts to open his eyes or mouth or to move his limbs (A. Pearce Gould). Erichsen called this condition "cerebral irritability." If a patient with very severe concussion and very rapid pulse is going to get better, the pulse will become slower. If a patient with severe concussion and a slow pulse is improving, the pulse will become normally rapid and stronger; if he is getting worse, it will become abnormally rapid and weaker. How long may concussion last? As von Bergmann well says: Concussion is transient in its manifestations. It is a matter of a few minutes or at most a few hours, and any prolongation of severe symptoms beyond this time, especially if they are intensifying as time goes on, indicates an associated injury. When the patient reacts from concussion, he will most probably vomit. Within twenty-four hours he usually improves, but is feverish and complains of headache and lassitude, sometimes becomes delirious, and in rare cases develops mania. After concussion recovery may be complete, but, on the contrary, a person's whole nature may change: he may develop hysteria, insanity, or epilepsy, and in many cases there is complaint for a long time of headache, insomnia, low spirits, and lassitude. Concussion may pervert or wipe out all memory of the causative accident and also, strange to say, of a varying period

preceding the accident. The loss of memory of the accident is permanent; the amnesia for a period preceding the accident may be permanent, but may only be temporary. Statements made regarding an accident by those who have had concussion must be received with many grains of salt. If the patient in concussion recedes from, instead of advancing toward, recovery, coma will set in or inflammation will develop. The prognosis is always uncertain. Any concussion producing more than very temporary unconsciousness is almost surely a serious injury, because considerable laceration has probably occurred.

Treatment.—In treating brain concussion bring about reaction by the administration of aromatic spirits of ammonia (no alcohol, as this agent excites the brain), by pouring a few drops of ammonia on a handkerchief and holding it near the nose, by surrounding the patient (who lies in bed with a pillow) with hot bottles, by hot irrigation of the head, by the application of mustard over the heart, and by the administration of enemata of hot coffee or hot saline fluid. Do not pour fluid into the patient's mouth until he becomes able to swallow easily. If he cannot easily swallow, rely on hot enemata and hypodermatic injections of strychnin. Place the patient in bed in a quiet room and watch him. If reaction is inordinate, apply cold to the head, give arterial sedatives and diuretics, and purge. For some days or for some weeks, according to the case, insist on an easy life. For many weeks after a grave concussion a patient must be kept away from business and be watched, because of the possibility of an abscess of the brain arising, and because of the liability of such patients to develop hysteria, neurasthenia, or insanity. Give a plain diet containing a minimum of meat, administer an occasional purgative, and secure sleep. Sleep can often be obtained by some simple expedient, such as the administration of warm milk, placing a hot-water bag to the abdomen or feet, or applying a mustard plaster for a short time to the back of the neck. In cases where obstinate wakefulness exists, it becomes necessary to give bromid, chloral, sulphonal, trional, or some other hypnotic. Morphin is avoided because it is thought to increase venous congestion of the brain, but the elder Gross often used it, especially in cerebral irritation. If signs of compression arise, it is best to trephine, as the compressing agent may be a clot (see page 703). If inflammation arises, some surgeons will not trephine; but it is wise and proper, especially if the damage seems to be localized, to incise the scalp and inspect the bone. If a fracture is discovered and the symptoms are serious, perform an exploratory trephining, open the dura, and secure drainage for inflammatory products.

In any severe concussion of the brain with contusion of the scalp the surgeon should at once incise the scalp and inspect the bone.

Compression of the Brain.—The combination of symptoms indicative of cerebral compression may be present in a number of different conditions. We find these symptoms in abscess of the brain, tumor of the brain, intracranial hemorrhage, foreign bodies, inflammatory exudate, and fracture of the skull with marked depression. The symptoms of compression are expressive of impairment of the functions of the entire brain by insufficient and imperfect circulation of blood, this impairment of circulation being the result of a lessening in capacity of the cavity containing the brain, its membranes, the blood-vessels, and the cerebrospinal fluid (von Bergmann).

If a brain tumor, or abscess, or blood-clot, or portion of depressed bone occupies space previously given to brain matter, vessels, etc., there is less room within the skull to contain the special structures; they are squeezed, and the circulation is greatly impeded. This condition is compression. The circulation is slow, and because of slow circulation the activity of the centers is finally inhibited. The cortex is temporarily stimulated and then depressed, because of impairment of nutrition. The medullary centers are first stimulated. The respiratory center is stimulated by retention of CO_2 in the blood, then the vasomotor center is stimulated, then the vagus, and finally, perhaps, the convulsive center (von Bergmann's "System of Practical Surgery"). The stimulation of the cerebral centers is followed after a time by weakening or actual paralysis. The centers are said to suffer in regular order, viz., the cortex, the corona radiata, the gray matter of the cord, and finally, the medulla (Huguenin). As von Bergmann points out, by the time the convulsive center becomes stimulated, the cortex is usually exhausted and the patient is unconscious. In compression the sensitive cortex first feels the effect and feels it most gravely, and the cortical impairment may last long after other trouble has passed. In some cases the cortex alone seems to be distinctly involved. When the vagus center is stimulated, the pulse becomes slow; later, as the center becomes exhausted, it becomes rapid and weak and this change has the same unfavorable significance as in concussion. If death occurs, it results from paralysis of respiration and not of circulation.

Symptoms.—The symptoms, known as *pressure symptoms*, are divided into those occurring during the period of stimulation and those occurring during the period of increasing exhaustion. The symptoms of the first stage are headache, vomiting, flushing of the face, contraction of the pupils, choked disc, mental excitement, elevation of blood-pressure, restlessness, and slowing of the pulse. The pulse becomes slow, regular, and strong. The symptoms of the second stage are heaviness, dulness, drowsiness, passing into stupor, and finally into coma, stertorous, after a time Cheyne-Stokes, respiration, a weak, intermittent, compressible, and increasingly rapid pulse, involuntary evacuations of feces and urine, and finally paralysis of respiration which causes death, the heart beating for a time after respiration has ceased (von Bergmann's "System of Practical Surgery").

The *headache* usually present in the first stage of compression is intense, persistent, sometimes general and sometimes more or less localized, and often aggravated by percussion of the cranium. It persists even in delirium, and the patient ceases to appreciate it only when unconsciousness begins. The *vomiting* is usually without nausea and is due to stimulation of the medullary center. At first vomiting may arise from taking food, but it soon continues independent of food. The tongue is probably clean. Cerebral vomiting is usually associated with severe headache. *Restlessness* is a pressure symptom in the stage of stimulation, and the patient rolls his head, tosses his body, and groans with pain. The *heart* does not begin to slow until the patient begins to be dull and drowsy, or until stupor arises, when the pulse slows and the tension rises. Finally it becomes very slow—perhaps less then 40 in a minute. If the condition grows worse, the pulse after a time suddenly becomes rapid and of low tension instead of slow and of high tension, a most unfavorable sign, indicating exhaustion and approaching par-

alysis of the vagus. In the stage of stimulation the patient is excited, unstable, delirious, and the condition of delirium gradually gives way to drowsiness, stupor, and coma. Before the patient is unconscious the pupils are contracted. When the patient is comatose, they are usually dilated, but may be contracted and respond slowly to light or not at all. If the conjunctival reflex is gone, they will not respond at all (Gowers). In a lesion making unilateral compression toward the base, the pupil on the side of the compressing cause is apt to be much dilated and even immobile. *Choked disc* begins in the stage of stimulation and continues to the end. That choked disc is due to intracranial pressure seems demonstrated by numerous operation reports, especially by Cushing, of Johns Hopkins Hospital, in which relief of pressure abates choked disc. After choked disc has existed for a variable period of time, dimness of vision becomes actual blindness. When vision is only dim from choked disc, relief of pressure may not only prevent blindness, but may improve sight. If actual blindness exists, it means optic atrophy, and sight will not return even if pressure is relieved. The existence of choked disc is determined by the use of the ophthalmoscope. The respirations become stertorous or snoring as coma develops because of the vibrations of the relaxed palate in the air-current, and the cheeks flap during expiration. As the activity of the respiratory center fails, the respirations become shallow and infrequent, or, perhaps, of the Cheyne-Stokes type. Gowers defines Cheyne-Stokes breathing as "alternating periods of decreasing and increasing depth of breathing, separated by a pause" (Lectures on Diseases of the Brain). The *unconsciousness of compression* may be sudden or gradual, may be partial or complete. Apoplexy and many traumatisms cause immediate unconsciousness. A meningeal hemorrhage causes a gradually increasing unconsciousness. A brain tumor causes heaviness, dulness, stupor, or, perhaps, after a long time, even coma. If compression comes on gradually, the brain more or less accommodates itself, and unconsciousness, if it occurs at all, is deferred late. A sudden increase of pressure may produce immediate unconsciousness. *Stupor* is partial unconsciousness, a condition in which a person lies as though asleep, though he rouses partially and temporarily when positively spoken to. In profound coma the limb reflexes are diminished or lost, the muscles are flaccid, and swallowing is impossible. In coma there is incontinence of feces and either incontinence or retention of urine. There may be the incontinence of retention. The *temperature* of a patient suffering from compression varies. In traumatic cases it may be at first subnormal and later normal or elevated. In inflammatory conditions it is elevated, except in abscess of the brain, in which it is subnormal in half the cases. After an apoplexy it is for a time subnormal, but as shock passes away it becomes somewhat elevated. Any sudden compression causes shock and temporarily subnormal temperature. Lesions of the pons and medulla cause elevation—perhaps remarkable elevation of temperature. In great or sudden brain compression complete coma always exists without voluntary movement. In cerebral compression *paralysis* may exist, which may be very limited (monoplegia), may be of one side (hemiplegia), or may be general. In hemorrhage into the interior of the brain the unconsciousness is immediate or nearly so. In bleeding from the middle meningeal artery a period of consciousness intervenes between the

injury and the coma, in which period blood collects and the coma comes on gradually. In compression from depressed fracture or from a foreign body the symptoms usually come on at once, but they may be deferred for some hours. Compression from inflammation or pus begins gradually after a considerable time has elapsed. The symptoms described as pressure symptoms are those of pure compression. When traumatism causes the condition, the compression symptoms are mingled with those of concussion, or perhaps of contusion or hemorrhage. The brain adjacent to any lesion causing compression suffers more than the brain distant from it. The blood-supply of the entire brain is affected, but the adjacent brain has its capillaries particularly and directly compressed. Hence the paralysis sometimes produced by certain lesions. The course of compression depends on the nature and persistence of the cause. Great temporary pressure may produce no permanent harm. Moderately severe pressure may be recovered from even after weeks of stupor. Great pressure, sufficient to induce coma, if not relieved quickly, will cause death.

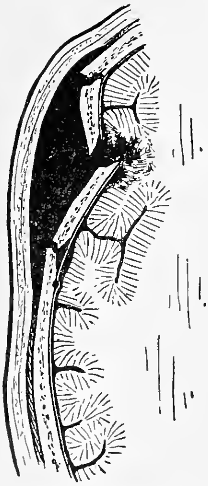


Fig. 397.—Fracture of skull with depressed fragments. Compression of brain by bone (Scudder).

Determination of the Cause of Coma in a Patient.—A **diagnosis** must be made between coma due to brain injury and the comatose condition of apoplexy, uremia, epilepsy, hysteria, diabetes, opium-poisoning, and alcoholic intoxication. In hospital practice cases of unconsciousness without a known history are frequent. In attempting to diagnosticate examine carefully for any evidence of traumatism, and inquire as to how and where the patient was found, if any fit occurred, and if a bottle or a pill-box was found near by or in the pockets. The surgeon should himself examine the pockets. Smell the breath to notice alcohol or opium, but always remember that a victim of Bright's disease is liable to apoplexy, that a man may be stricken with apoplexy while he is drunk, and may fracture his skull by falling when under the influence of opium or of alcohol. The odor of acetone (violets) on the breath or in the urine indicates the existence of diabetes. Draw the urine with the catheter if any water is in the bladder. Examine the urine for albumin, acetone, and sugar, and take the specific gravity. In doubtful cases of coma have an ophthalmologist use the ophthalmoscope. He might find optic atrophy indicative of Bright's disease or choked disc indicating compression. The cerebrospinal fluid obtained by lumbar puncture will contain blood if hemorrhage has taken place beneath the cerebral dura or in a ventricle of the brain. This test is valuable in fracture of the base of the skull, for in this condition cerebrospinal fluid is usually bloody. In *post-epileptic coma* the temperature is never below normal, there are no unilateral symptoms, the condition resembles sleep, and the patient can be aroused. *Hysterical coma* occurs in boys and women; there are no objective symptoms, and the patient, though swallowing what is put into his mouth, cannot be roused. In *uremia*, besides the condition of the urine (and always remember that a person with albuminuria is apt to

develop apoplexy), there is a persistent subnormal temperature, and convulsions are prone to occur. There is perhaps edema of the legs, and paralysis and stertor are absent. In *apoplexy* hemiplegia exists, and the initial temperature is for a short time subnormal. A single convulsion may have ushered in the case. *Alcoholic unconsciousness* is often diagnosticated when apoplexy really exists. A man will smell of alcohol who has had one drink, but one drink will not produce coma; hence the smell of alcohol is not conclusive. In any case of doubt some hours of watching will clear up the diagnosis. Regard a doubtful case as serious until the truth is clear. In *opium-poisoning* the pupils are contracted to a pin-point, the respirations are usually slow, shallow, and quiet, and may be stertorous, but there is no paralysis. Always remember that hemorrhage into the pons will produce pin-point pupils, but it also causes paralysis (crossed paralysis if in the lower half of the pons), and high temperature with sweating. In opium-poisoning the temperature is subnormal. In *diabetic coma* the pupils will react to a very bright light, the temperature is subnormal, and the breath and the urine smell of acetone.

Treatment of Brain Compression.—The treatment of brain-compression depends on the cause. Hemorrhage (extradural or subdural) requires trephining and arrest of bleeding; coma from depressed fracture demands trephining and elevation; foreign bodies must be removed; abscesses must be evacuated; some tumors are to be removed. In many tumor cases the growth is not removed, but a decompression operation is performed (page 728).

In cerebral compression, if death is threatened by respiratory failure, make artificial respiration and at once trephine over the supposed region of compression. Horsley has shown that irrigation of the

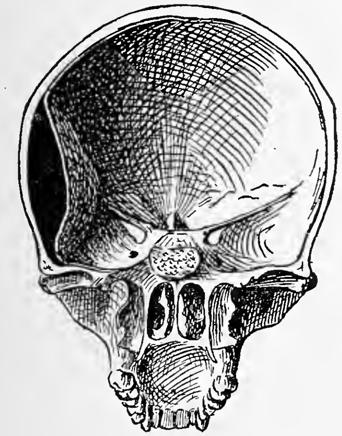


Fig. 398.—Frontal section of skull. Middle meningeal hemorrhage. The dura bulges inward toward the skull cavity (diagram) (Scudder).

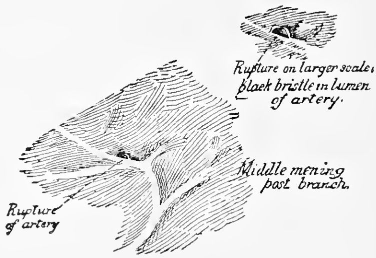


Fig. 399.—A case of rupture of middle meningeal artery. Preparation of dura. In the Warren Museum. The specimen is viewed from the outer side (Scudder).

head with hot water is of great value in bringing about reaction from shock in cases of brain injury.

Intracranial hemorrhage may be either *spontaneous* or *traumatic*. In the vast majority of instances spontaneous hemorrhage comes from the lenticulostriate artery (Charcot's artery of cerebral hemorrhage), and produces apoplexy, a disease belonging to the physician, except in some ingravescent cases, for which ligation of the common carotid on the same side as the rupture

may be indicated. In adults traumatism is almost always the cause of a meningeal hemorrhage. The blood may flow from a sinus, from the middle meningeal artery or one of its branches, or from vessels of the pia. Traumatism during delivery is an occasional cause of hemorrhage from the middle meningeal artery (Richardiére) and a not unusual cause of hemorrhage from cortical veins. Violent paroxysms of coughing in whooping-cough occasionally produce extradural hemorrhage or subdural hemorrhage. Geo. S. Brown reports such a case. He diagnosticated the condition and operated successfully ("New York Med. Jour.," April 25, 1903).

Traumatic Meningeal Hemorrhage.—Hemorrhage may take place—(1) between the bone and the dura (*extradural*); (2) between the dura and the brain (*subdural*); and (3) in the brain substance (*cerebral*).

1. **Extradural hemorrhage** arises usually from the middle meningeal artery or from one of its branches. A spicule of bone may penetrate a venous sinus and produce extradural hemorrhage, or a sinus may rupture. Rupture of the meningeal artery or one of its branches is usually, but not always, accompanied by fracture (Fig. 400); in fact, in some cases not even a bruise can be found (Fig. 399). The ruptured vessel may be upon the opposite side to that on which the force was applied, hence the evidence of scalp injury is not a certain sign of the side of the skull involved. The accident may or may not cause temporary unconsciousness; but even if it does, from this unconsciousness the patient almost always reacts, and there is a *distinct period of consciousness* between the accident and the lasting coma, the coma being due to pressure from a continually increasing mass of extravasated blood (Fig. 398). If the main trunk or a large branch is ruptured, the period of consciousness is short; if a small branch is ruptured, the period of consciousness is prolonged for hours or perhaps for days. As the clot forms and enlarges the patient becomes heavy, dull, stupid, and sleepy; he sleeps so soundly he can scarcely be aroused, and snores loudly, and finally passes into stupor and then into coma. The other signs of this condition are paralysis of the side opposite the blood-clot (not necessarily of the side opposite the point of application of the force, for the artery may rupture from contre-coup on the uninjured side); this paralysis is apt at first to be localized, but it gradually and progressively widens its domain. If the clot extends toward the base, the pupil on the same side as the clot ceases to react to light, becomes immobile, and dilates widely, and, if the clot be on the left side, aphasia may be noted. As the clot enlarges adjacent centers become involved. The face becomes paralyzed, then the arm, and finally the leg. Not unusually epileptiform attacks occur, starting in discharges from the centers which are irritated by the advancing clot before their function is abolished by pressure. The pulse becomes full, strong, usually slow, but occasionally frequent; the breathing becomes stertorous; the temperature rises, that of the

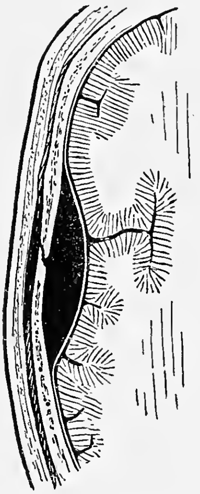


Fig. 400.—Fracture of skull with middle meningeal hemorrhage. Compression of brain by blood (Scudder).

paralyzed side exceeding that of the sound side. In a compound fracture the pressure of escaping blood may force brain matter out of the wound. In extradural hemorrhage from a sinus the symptoms cannot be differentiated from those produced by arterial rupture.

Treatment.—In treating extradural hemorrhage localize the clot, not by the seat of the wound or contusion, but entirely by the symptoms. In a doubtful case endeavor to bring about reaction; but if the state of shock deepens or does not improve and if pressure-symptoms increase, operate at once. To reach the middle meningeal artery or its anterior branch trephine one and one-fourth inches back of the external angular process, at the level of the upper border of the orbit (Figs. 387 and 396). If this incision does not expose the clot, trephine again at the level of the upper border of the orbit and just below the parietal eminence (Fig. 396). The first incision gives access to the main trunk and to the anterior branch; the second incision exposes the posterior branch. If signs indicate that the clot is traveling to the base, the trephine should be used half an inch lower than the point first directed. Arrest bleeding by a suture ligature or by packing (page 389), and always open the dura and inspect the brain. By this procedure a subdural hemorrhage may be discovered which, without it, would have been missed. Drainage must be employed.

2. **Subdural hemorrhage** is usually due to depressed fracture and rupture

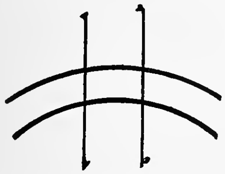


Fig. 401.—Section of outer and inner tables, with two parallel lines (after Agnew).

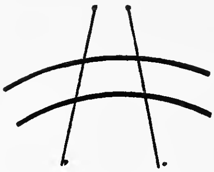


Fig. 402.—Greater yielding of the inner table than of the outer after the application of violence (after Agnew).

of the middle cerebral artery or of a number of small vessels. The *symptoms* are identical with those of extradural bleeding, but are usually very rapid in onset and are accompanied by a more distinct drop in temperature and graver depression. The cerebrospinal fluid obtained by lumbar puncture is bloody.

The *treatment* is trephining at the first point named in the previous article, enlarging the opening upward and backward with a rongeur, opening the dura, turning out the clot, ligating the bleeding point or packing, elevating any depression of bone, draining, and stitching the dura with catgut. Hemorrhage from internal pachymeningitis requires the same treatment.

3. **Cerebral Hemorrhage.**—The *symptoms* of cerebral hemorrhage are identical with those of apoplexy. The *treatment* is the same as that for apoplexy, except in ingravescent cases, when the common carotid on the same side as the clot may be ligated.

Rupture of a sinus may arise without a bone injury, but is usually due to a compound fracture. A sinus may be wounded during a brain operation. The **treatment,** if the rupture happens from fracture, is trephining. Enlarge the bone opening by the rongeur, pack with *one large piece* of iodoform

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gauze, or catch the rent with hemostatic forceps, leaving them in place for three or four days, or apply a lateral ligature or a suture ligature. Elevate depressed bone. If during an operation a sinus should be wounded, use a lateral ligature, a suture ligature, or control hemorrhage by packing.

Intracranial Hemorrhage in the Newborn.—Certainly most of the cases of birth palsy seen in children are the result of subdural hemorrhage at birth and damage of the cortical motor area. In such conditions there is spastic paralysis of the hemiplegic type, or if both hemispheres suffered there is spastic diplegia and usually amentia (Cushing, in "Am. Jour. Med. Sciences," Oct., 1905). It has not been the custom to operate for hemorrhage in the newborn; most of the cases do not die, and remain for life weakened and paralyzed, or epileptic or idiotic.

The hemorrhage, in cases of birth palsy, is, as Cushing points out, usually venous and due to "rupture of some of the delicate and poorly supported venous radicles of the cerebral cortex" ("Am. Jour. Med. Sciences," Oct., 1905). It may result from traumatism due to bone overlapping or forceps pressure during parturition, or may arise during asphyxia after birth. Cushing discovered in examining stillborn infants and infants that died soon after birth that many of them died with cortical hemorrhage. In some the extravasations were very large—in fact, completely overlying a cerebral hemisphere. In some they were much smaller. In one the clot was in the cerebellar fossa.

The vessels usually torn are on one side and are the unsupported venous radicles which enter the longitudinal sinus, hence the leg center of one side is the cortical area most apt to be gravely damaged. If the vessels of both sides are torn, a bilateral cortical lesion results.

Symptoms of Hemorrhage.—In Cushing's masterly paper ("Am. Jour. Med. Sciences," Oct., 1905) the symptoms of recent hemorrhage are set forth. There is the history of a long and difficult labor, forceps perhaps having been used, or a history of postpartum asphyxiation. The fontanelle bulges and perhaps does not pulsate. The fluid obtained by lumbar puncture contains blood-corpuscles. There is usually twitching and, as a rule, convulsions occur. They may occur soon after birth or not for several days. When they occur soon, they may be general; when they occur later, they may be unilateral. Paralysis is rare in the early days after birth. There may be alterations in the circulation and respiration. Pupillary alteration and ocular palsy seldom occur. If the child is not operated upon it may die or it may apparently recover. If it apparently recovers after a considerable hemorrhage, several months may pass before ominous symptoms are recognized. The late manifestations of the disease may be "spastic palsies, or blindness, or deafness, or feeble-mindedness, or, in severe cases, even complete amentia" (Cushing).

Treatment.—Osteoplastic craniotomy in the parietal region, on one side or both, according to the unilateral or bilateral nature of the hemorrhage; opening of the dura; washing out and turning out the clot; suturing the dura and closing the scalp without drainage. Cushing reports 4 cases, in one of which operation was done on both sides. He says chloroform should be given and that the parietal bone can be cut with blunt, curved scissors.

Fractures of the skull may be *simple*, *compound*, *depressed*, *non-depressed*, or *punctured*. They are divided into fracture of the *vault*, usually due to direct force, and fractures of the *base*, due to extension of fractures of the

vault, to indirect violence (a fall upon the feet, the buttocks, or the vault), to forcing of the condyles of the lower jaw against or through the base, or to foreign bodies breaking through the orbit, vault of the pharynx, the ear, or the roof of the nostrils. Fracture by contre-coup, which occurs on the side opposite the point of application of the violence, is very rare. Fractures of the skull are uncommon in early youth, but they are much more frequent in the aged. Usually the entire thickness of the bone is fractured, but either the outer or the inner table (Fig. 403) may be broken alone. In complete fractures the inner table is broken more extensively than is the outer table, because the inner table is the more brittle, because the force diffuses, and also, as Agnew taught, because the inner table is part of a smaller curve than is the outer table, and violence forces bone-elements together at the outer table, but tears them asunder at the inner table (Figs. 401, 402).

Fractures of the Vault.—A fracture of the vault of the skull may be simple and undepressed, or it may be depressed (Figs. 397 and 403), compound, or comminuted. A mere crack may exist in a bone, and if a rent exists in the soft parts, a bit of dirt or a hair may be caught in the crack. Fractures of the vault arise from direct force. A *fissure* may escape recognition, although in some cases percussion gives a "cracked-pot" sound. Any considerable depression can be detected. In a simple fracture occasionally the cerebrospinal fluid collects under the scalp and forms a tumor which pulsates and becomes tense on forcible expiration (spurious meningocele, page 695). Compound fracture can be readily recognized, but do not mistake a suture, a Wormian bone, or a tear in the pericranium for a fracture. A fissured fracture is marked by a dark line of blood which *sponging will not remove.* Fracture of the inner table alone can only be suspected. The prognosis of fracture of the vault depends upon the extent of brain injury rather than upon the extent of bone injury. Simple fractures unite by bone; compound fractures with loss of bone unite only by fibrous tissue. The dangers may be *immediate* (hemorrhage, brain injury, and septic inflammation) or be *distant* (epilepsy, insanity, and persistent headache).

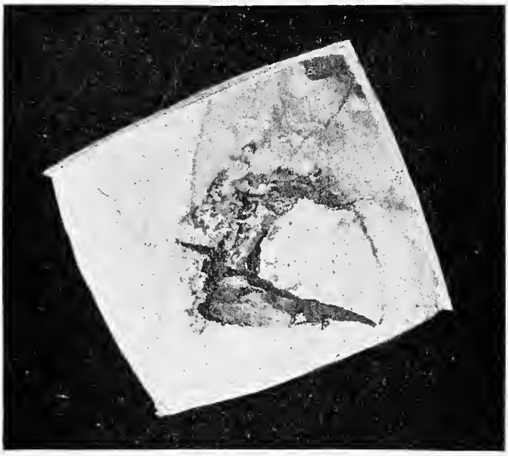


Fig. 403.—Fracture of the vault with extensive depression of the inner table ("American Text-book of Surgery").

Treatment.—The mortality of fracture of the skull was formerly much greater than at present. Before the days of antisepsis it was 51 per cent. (Harte). Trephining is performed much oftener than was once the custom, and is vastly safer. Out of 26 trephined cases, 3 died (Harte). In any case of fracture of the skull endeavor to bring about reaction before operating, unless the signs of pressure continually increase or the evidences of shock

remain unimproved or become graver. A *simple fracture without depression* and *without brain symptoms* is treated expectantly (by rest, quiet, low diet, purgation, moderate elevation of and cold to the head, and arterial sedatives). A *simple fracture with moderate depression* and *without cerebral symptoms* is treated expectantly, and so also is a *simple fracture* in which *symptoms existed but are abating*. *Simple fracture with marked depression* requires immediate trephining, even when brain symptoms are absent. Some surgeons make an exception in young children, and wait a while before trephining, in the expectation that the expansile brain will lift the depressed but elastic bone up to the level. Trephining in cases where no symptoms exist, although there is marked depression, often prevents disastrous consequences arising in the future, and is known as "*preventive trephining*" (Agnew, Keen,

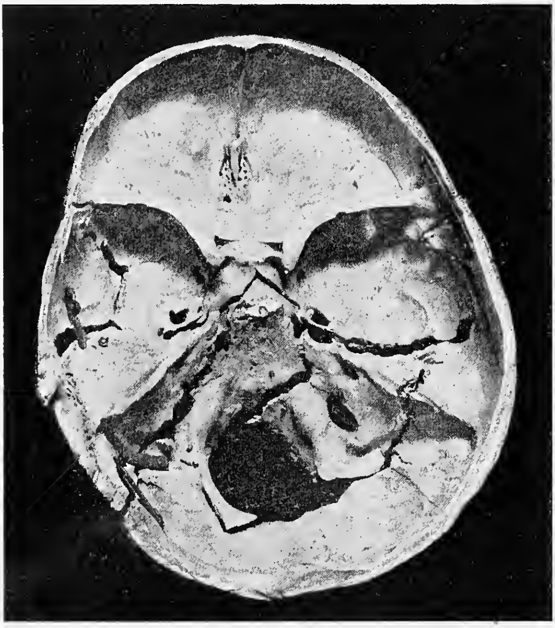


Fig. 404.—Extensive fracture of the base of the skull ("American Text-book of Surgery").

Horsley, Macewen, von Bergmann, and others). In all *compound fractures* shave and asepticize the entire scalp, enlarge the incision, and explore the bone. If a fissure exists, it must be asepticized, and if a hair or other foreign body is found in it, in order to effect removal and secure asepsis the outer table of the skull must be cut away with a chisel, the fissure being thus converted into a broad groove. In a *compound fracture with much depression* trephine, elevate, and irrigate. In any fracture trephine if distinct symptoms exist. In punctured wounds of the brain (*punctured fractures*) *always* trephine, open the dura, and disinfect (Keen). In any case of fracture of the vault where trephining has been performed it is wise to open the dura and examine the brain.

Fractures of the Base.—A fracture of the base of the skull may exist in

only one of the three fossæ, in two of them, or it may involve all. Fig. 404 shows an extensive fracture of the base of the skull. The middle fossa is oftenest involved. Fracture of the posterior fossa is the most fatal. These fractures may be due to direct volence, to indirect force, and to extension of a fracture of the vault. Extension from the vault is always by the shortest route. Fracture by direct violence may arise from the penetration of the nasal roof, the orbital roof, or the pharyngeal roof by a foreign body. The posterior fossa may suffer from a fracture by direct violence applied to the neck. Fractures by indirect force may arise from blows upon the frontal bone (the orbital portion of the frontal or the cribriform process of the ethmoid breaking), from falls upon the chin (the condyle of the jaw breaking the middle fossa), or from falls upon the buttocks, the knees, or the feet (fracture occurring in the posterior fossa). The base is very rarely broken by contre-coup (Treves).

Symptoms.—Fractures of the base of the skull are apt to be compound. A solution of continuity in the pharynx, roof of the nares, orbit, or ear permits access of air to the seat of fracture and allows blood and cerebrospinal fluid to flow externally. In *fracture of the anterior fossa* the fracture may be compound, because of laceration of the mucous membrane of the nares or of the conjunctiva. Blood may run from the nose, its source being the vessels of the mucous membrane or the dura, the fracture being compound. Epistaxis does not prove the fracture to be compound, but only suggests it; but if the epistaxis is prolonged, the probability is greatly increased; and if the flow of blood is succeeded by a flow of cerebrospinal fluid, the diagnosis of compound fracture is positive. Cerebrospinal fluid appears only when the mucous membrane, the dura, and the arachnoid are each lacerated (Treves). In fractures of the anterior fossa blood is apt to flow into the orbit, producing *subconjunctival ecchymosis*, and some blood is often swallowed and vomited. In *fractures of the middle fossa* blood may flow from the ear through a tear in the tympanum, its source being the vessels of the tympanum, the meningeal vessels, or a sinus. Blood may flow through the Eustachian tube and come from the nose, may be spit up, or may be swallowed and vomited. In some cases a quantity of cerebrospinal fluid flows from the ear, the discharge being increased by expiratory effort and a position which favors gravity. The cerebrospinal fluid must not be confused with either blood-serum or liquor Cotunnii. The cerebrospinal fluid is always present in large amount; the liquor Cotunnii can be present only in minute amount. Blood-serum is highly albuminous; cerebrospinal fluid is a serous fluid of very low specific gravity, never shows more than a trace of albumin, and contains considerable chlorid of sodium and in some instances sugar, which, when present, reacts to Trommer's and to Moore's tests, but does not reflect polarized light nor ferment with yeast (Keetley, from Collins). Treves states * that cerebrospinal fluid cannot flow from the ear in fractures of the middle fossa—(1) unless the line of fracture crosses the internal meatus; (2) unless the prolongation of the membranes into the meatus is torn; (3) unless a communication exists between the internal ear and tympanum; and (4) unless the drum-membrane is torn. Miles, of Edinburgh,† claims that bleeding from the ear followed by a flow

* "Applied Anatomy."
† Edinburgh Med. Jour., Nov., 1895.

of cerebrospinal fluid is not pathognomonic of fracture of the middle fossa of the base. He maintains that when the drum is ruptured, we may have these signs; when bone is not broken, the chief source of the blood being the vessels of the pia and temporo-sphenoidal lobe, the blood and cerebrospinal fluid flowing inside the sheath of the auditory nerve, passing into the vestibule, through the lamina cribrosa, and from the vestibule into the middle ear, finding exits from this space by way of the Eustachian tube and also through the rent in the drum-membrane. Profuse serous discharge may flow from the ear after an injury without fracture when the drum is ruptured, the fluid coming from the cells of the mastoid. It must be understood that fracture of the base may exist when there is no flow of blood or of serous fluid. A fracture of the middle fossa is usually compound, made so, even when the drum is not ruptured, by the Eustachian tube, and there is often paralysis of the seventh or eighth nerve or of both of them. In *fracture of the posterior fossa* there is usually respiratory derangement and blood accumulates beneath the deep fascia and produces discoloration in the line of the posterior auricular artery (*Battle's sign*), the discoloration first appearing near the tip of the mastoid. The discoloration appears in the line of nerves and vessels which emerge from the deep fascia, the vessels passing through openings and the extravasated blood emerging from the same openings. Fractures of the posterior fossa are apt to be compound through the pharynx, and in such cases the patient spits or vomits blood. Fractures of the posterior fossa are more fatal than fractures in either of the other fossæ because of the adjacency of vital centers. Fractures of the base are apt to be associated with *paralysis of cranial nerves*. *Optic neuritis* often arises after the first week. In fractures of the base the temperature is subnormal during the shock, rises to 100° to 101°, falls again to about normal, and remains normal or subnormal unless there be inflammation or sepsis. Lumbar puncture may obtain bloody fluid. Such a finding means subarachnoid bleeding and indicates fracture. Harte ("Annals of Surgery," Oct., 1901) has collected 46 positive cases of fracture of the base of the skull from the records of the Pennsylvania Hospital; 35.5 per cent. recovered.

Treatment.—In treating a compound fracture of the base of the skull collect any serous discharge and analyze it, and disinfect any cavity involved. In fractures of the middle fossa with ruptured drum clean the ear mechanically, wash it out with a stream of warm corrosive sublimate solution of a strength of 1 : 2000 (turn the head toward the affected side while washing, so that the mercurial solution will not run down the Eustachian tube), wash with normal salt solution, insufflate iodoform, insert a piece of iodoform gauze, and apply an antiseptic dressing. Several times daily the ear is to be irrigated, and insufflated with iodoform. The nasopharynx must be frequently irrigated with normal salt solution or boric-acid solution, and insufflated with iodoform. The conjunctival sac is frequently irrigated with boric-acid solution. If after a head injury blood accumulates back of the drum, this membrane should be incised to permit of drainage and disinfection. In fractures of both the middle and anterior fossæ and in fractures of the posterior fossa communicating with the pharynx the nasopharynx must always be cleaned. The exact method depends on the choice of the surgeon. We may wash out these cavities frequently with hot water, next with peroxid of hydrogen, and

finally with boric-acid solution, or can simply use normal salt solution. After washing, insufflate the nasopharynx with iodoform. Repeat the cleansing at regular intervals and also cleanse the conjunctival sac frequently. In some cases drainage has been obtained from the anterior fossa by breaking through the cribriform plate and introducing a tube by way of the nostril (Allis), and from the middle fossa by trephining above and behind the external auditory meatus. In a compound fracture of the orbit disinfect and drain. It may be necessary to trephine the roof of the orbit to secure drainage. In fracture of the posterior fossa examine to see if the fracture is compound, into the pharynx, and if it is, cleanse with great care the nasopharynx and mouth, as previously directed. In a very extensive fracture of the base, besides use of the methods set forth above, the entire head should be shaved and a plaster-of-Paris cap be applied. A patient with fracture of the base must be put into a quiet and darkened room and be kept upon a low diet, sleep being secured, and the bowels and bladder being attended to. If we are uncertain as to whether a fracture exists or not, keep the patient quiet and in a darkened room and on a low diet. Attend to the bladder, keep the bowels loose, examine the nasopharynx with mirrors and the ear-drum through a speculum.

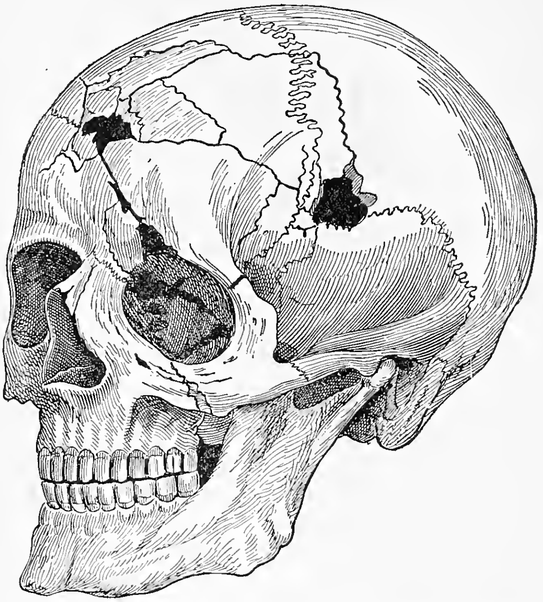


Fig. 405.—Extensively comminuted gunshot-fracture of the skull (after von Bergmann).

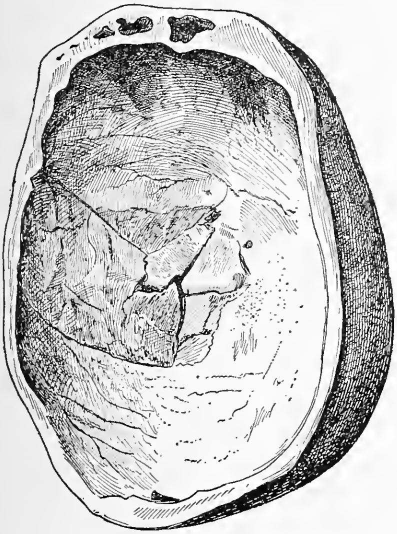


Fig. 406.—Gunshot-fracture of internal table of the skull (after von Bergmann).

Wounds of the brain are produced by violence and by foreign bodies (knives, bullets, etc.). Except when due to penetration of a fontanelle in a

child or of a parietal foramen in adults, wounds of the brain are accompanied by fracture of the skull. These wounds are very dangerous; foreign bodies (bone, hair, clothing, etc.) are often lodged in the brain, hemorrhage is usually severe, and sepsis is almost inevitable without proper treatment. Such cases are very fatal, though some astonishing recoveries are on record. Figs. 405 and 406 show gunshot-fractures of the skull.

The **symptoms** of brain-wounds may be slight and long-deferred or may be immediate and overwhelming; they depend upon the site and extent of the injury. Localizing symptoms may exist, and encephalitis with coma is apt to arise. Abscess not unusually follows.

In treating wounds of the brain always shave the entire scalp and examine the weapon, if possible, to see if a piece were broken off. Asepticize, enlarge the wound, trephine, arrest bleeding, elevate any depression, remove foreign bodies, irrigate the wound, drain with gauze, suture the dura, and dress.

Gunshot-wounds of the Head.—A *penetrating* wound is one in which the bullet enters the head, but does not emerge; a *perforating* wound is one in which the bullet passes through the head and emerges. The bullet of the modern rifle will rarely lodge, but a pistol-bullet will often lodge. The wound of entrance is small; the wound of exit is large. At the wound of entrance the inner table is more extensively fractured than the outer table; at the wound of exit the outer table is more widely broken than the inner table. In these cases there is always great concussion, and concussion-symptoms exist even when the bullet has entered the brain. In moderate concussion the action of the heart is retarded; in severe concussion it is accelerated* (page 698). A bullet may be lodged within the cranium when merely a fracture without a bullet-hole can be detected. In these cases the bullet produces a fracture and enters the cranium, and then the depressed bone flies back into place (v. Bergmann). In such cases, if complete perforation occurs, the one existing opening is the opening of exit. A bullet may lodge in the bone, between the dura and the bone, in the brain, between the dura and bone of the opposite side, or in the bone of the opposite side, in the nasal fossa, maxillary antrum, or orbit. Always examine the side of the head opposite to the wound of entrance to determine if there is any bulging or fracture. A bullet may pass across the brain and be deflected from the inner surface of the skull (Fluhrer). Ruth does not believe the bullet can rebound from the opposite wall.† The secondary **symptoms** of gunshot-wounds of the head are varied and uncertain, and may not be observed at all before death. Fowler wisely points out that a patient with a gunshot-wound of the head may have also received other injuries, and the other injuries may be in part, at least, responsible for cerebral symptoms.

Treatment.—Endeavor to bring about reaction (see Concussion). In severe cases apply heat to the head and make artificial respiration. It will sometimes be necessary to operate while artificial respiration is being made. In treating gunshot-wounds of the head shave and asepticize the whole scalp, disinfect the entire track of the ball, and arrest hemorrhage at the wounds of entrance and exit, using the rongeur to expose the bleeding points if the bullet be large, employing the trephine if it be small. If the bullet has emerged and has been picked up, examine it to see if it is entire. The bullet, if retained,

* Fowler, in Annals of Surgery, Nov., 1895.
† See the instructive article by Fowler, in Annals of Surgery, Nov., 1895.

is to be sought for. Place the head in such a position that the track of the ball will be vertical, then introduce Fluhrer's aluminum probe or Senn's probe, and let it find its way by gravity. The probe may find the ball near the wound of entrance, in which case extract the ball with forceps; or the probe may find the ball near the opposite side of the head, in which case make a counter-opening through the bone at a point the probe would touch if it were pushed entirely across. Take a new and *clean* rubber catheter (No. 9, French), insert a stylet, and carry the catheter through the wound (Keen). Knowing the depth of the ball, search for it around the catheter-tube as an axis, and when found, extract it. After extraction drain the wound by means of a tube. When a counter-opening exists, drain through and through. If the ball cannot be detected, drain by a tube carried to the depths of the wound. After dressing always place the head in a position favorable to drainage. Fluhrer tells us that when a counter-opening fails to disclose the bullet, use the new opening as a doorway through which to search for the ball. He believes the bullet is not unusually deflected. The angle of deflection is somewhat greater than the angle of incidence, and the bullet is apt to fall a little toward the base. Splinters of bone are often driven into the brain by a bullet, and these should be removed whether the ball is found.or not. Several varieties of probes have been commended. Fluhrer uses a large-sized aluminum probe. Senn uses

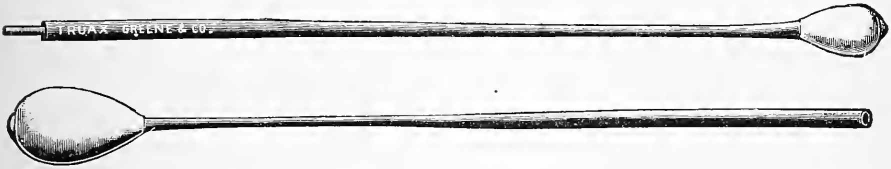


Fig. 407.—Senn's bullet-probe.

an instrument shaped like the Nélaton probe, but of the same diameter as the bullet (Fig. 407). (Of course, the porcelain probe will not show a black mark from contact with a hard-jacketed bullet.) Fowler uses a graduated pressure probe; so long as the pressure is within the limits of the spring, as shown by the scale, the probe is in the bullet-track. Girdner's telephonic probe is a valuable aid to diagnosis. Bullets are now located by the Röntgen rays. There can be no doubt that many gunshot-wounds have been recovered from without operation, and it is beyond question that many deaths follow operation (about $33\frac{1}{3}$ per cent., according to Hahn). Von Bergmann is so impressed with these facts that he does not operate when cerebral symptoms are absent.

Prolapse of the Brain and Hernia of the Brain.—In a compound fracture, especially a gunshot-fracture, with torn dura and pia, brain-matter may emerge from the wound. In fracture of the base brain-matter may enter the orbit, the nose, or the ear. A flow of brain-matter may continue from a wound for many hours. A week or more after an injury a portion of the brain may protrude or prolapse. To this condition the term *prolapse* should be applied. In many instances the protrusion is covered with pia, but if the pia were torn or cut, it will not be a covering. This protrusion emerges from the opening in the skull, mounts up, growing larger and larger, until it may

become the size of a fist. It usually pulsates. When bare it is soft, lobulated, of a dirty white color, pulsating, painless to the touch, often bleeding, and sometimes discharging cerebrospinal fluid. Death may soon follow such protrusion, but the protruding mass may become necrotic and be sloughed off, a granulating surface remaining, which heals. *Hernia cerebri* (Fig. 408) sometimes follows operations upon the brain or injuries of the skull and dura, when large pieces of bone have been removed or when the dura has been widely cut or torn and has not been carefully sutured. The condition is due to increased cerebral pressure. Hernia of the brain is protrusion through the dura but not through the scalp, the scalp wound being healed above the protrusion. In a decompression operation we deliberately create a hernia of the brain. Prolapse of the brain is treated by antiseptic dressings and perhaps by craniotomy to relieve pressure. Skin-grafting benefits some cases. Pressure is dangerous. Excision by the knife or cautery seldom does no good. Hernia in some cases can be treated by repeated lumbar punctures, in some others by craniotomy of the opposite side of the skull.

Fig. 408.—Hernia cerebri under scalp after operation for brain tumor (W. W. Keen).

Fungus Cerebri (Fig. 409).—When the brain is exposed, a granuloma may grow from the neuroglia and fungate through the skull. This condition is fungus cerebri and is not composed of brain-matter. It is due to infection of the brain, and is most frequent when a bit of bone or some other foreign body is retained. A fungus is soft to the touch, is livid in hue, bleeds easily, frequently contains multiple foci of suppuration, and pulsates. It often attains the size of a small orange. It is treated by removing the granulations and any foreign body, and applying, with moderate pressure, aseptic dressing soaked in alcohol. After healing, a depression marks the site of the fungus.

Fig. 409.—Fungus cerebri (W. W. Keen).

Traumatic inflammation of the brain and its membranes is divided into *encephalitis* or *cerebritis*, inflammation of the cerebrum; *cerebellitis*, inflammation of the cerebellum; *meningitis*, inflammation of the meninges; *arachnitis*, inflammation of the arachnoid; *pachymeningitis*, inflammation of the dura; and *leptomeningitis*, inflammation of the arachnoid and pia.

Pachymeningitis Externa.—Inflammation of the external layer of the dura is called *pachymeningitis externa*. It may arise from tumor, caries, necrosis, middle-ear disease, sunstroke, or traumatism. Syphilis is a not unusual cause. The other membranes may become involved. Suppuration may arise, having extended by contiguity from neighboring parts. The **symptoms** of pachymeningitis externa are uncertain. They resemble often those of leptomeningitis (page 716). Pressure-symptoms may arise. Headache is always present. Paralysis may or may not exist. If pus forms, the ordinary constitutional symptoms of suppuration are evident (high temperature and sweats), not the symptoms of abscess in the brain. In a severe case the other membranes become involved.

The **treatment** consists in removing the cause (carious bone, pus, middle-ear disease). In pachymeningitis from traumatism it is sometimes advisable to trephine in order to drain inflammatory products; in a case with localizing symptoms always trephine; in an ordinary case, without pus and with no evidences of traumatism, use wet cups back of the mastoid processes, apply an ice-bag to the head, and purge by means of calomel. Administer iodid of potassium in most cases. If sunstroke is the cause, treat according to ordinary medical rules.

Pachymeningitis Interna.—This term means inflammation of the inner layer of the dura. Inflammation may extend from the pia, or from the outer layer of the dura. The disease is most often met with in infants and in the chronic insane, but may occur in those not insane in late middle age or beginning old age. The form known as *hematoma* of the dura mater, or *pachymeningitis interna hæmorrhagica*, may arise during infectious disease (typhoid fever and rheumatism), in persons of the hemorrhagic diathesis, in diseases causing atrophy of the brain, in chronic diseases of the heart and kidneys, and in syphilitics. Among the exciting causes are traumatism, inflammation in adjacent parts, and, especially, the abuse of alcohol. In this disease blood is extravasated on the inner surface of the dura. Many observers do not class hemorrhagic pachymeningitis as inflammation, but regard the hemorrhage as primary.

The **symptoms** of internal pachymeningitis are very chronic, come on gradually, are not characteristic, and may be absent. They consist usually of mental irritability or excitement, followed perhaps by hebetude and persistent headache; and apoplectiform attacks, with contraction of the pupil, slow pulse, and vomiting; there may also be muscular rigidity and spasm of the extremities. Choked disc is not infrequent; localizing symptoms may be made out, and coma is apt to arise. Cranial nerves are seldom affected.

The **treatment** is operation. This is unpromising, but Munro saved 1 case out of 5 ("Chicago Med. Recorder," Dec., 1902).

Acute leptomeningitis is a purulent inflammation of the soft membranes of the brain. The pathological changes can be noted in the pia and in

the brain-substance. The brain is edematous, the pia purulent, the convolutions are flattened, the ventricles are distended with fluid, and hemorrhages occur into the brain-substance. Pus may be localized upon the pia, but it is usually diffused over one hemisphere or over both. Various organisms may be found, especially streptococci, staphylococci, and diplococci. In some cases we find the bacillus pyocyaneus or the bacillus pyocyaneus fœtidus, which is identical with the colon bacillus and with the bacillus meningitis purulenta (Park). Saprophytic organisms are occasionally present. This disease may be acute or chronic, and a severe case is spoken of as *encephalitis*. *Secondary leptomeningitis* is apt to affect the convexity; *primary leptomeningitis* is apt to affect the base.

The **causes** of leptomeningitis are epidemic cerebrospinal fever, tuberculosis, acute general disease (pneumonia, typhoid, erysipelas, and rheumatism), bone-diseases, traumatisms, middle-ear disease, syphilis, and sunstroke. The tissues of the *pia* and the cerebrospinal fluid contain diplococci identical with pneumococci. Infection may take place by various avenues. It may pass from the nose by way of the Eustachian tube to the ear, or from the nose to the frontal sinus or ethmoid sinuses (Hirt), and from these situations to the brain. It may pass from the middle ear or mastoid to the membranes of the brain. In fractures at the base the organisms enter by way of the pharynx and the Eustachian tube, or the ear. The **symptoms** of acute leptomeningitis are violent headache persisting during delirium, flushing of the face, rigidity of the neck, cerebral vomiting, a slow pulse, elevated temperature, photophobia, contraction of the pupils, intolerance of sound, hyperesthesia of the skin and muscles, and delirium passing into stupor and coma. A chill or a succession of chills may occur. Choked disc, strabismus, and nystagmus are not unusual. Convulsions or paralyses may occur. Death is the rule within one week. The **treatment** usually consists of purgation with calomel; bleeding behind the mastoid process; cold to the head; warm baths with cold affusions to the head; iodid of potassium, bromid of potassium, or morphin for vomiting and headache. Lumbar puncture is usually performed, but for diagnostic rather than therapeutic reasons. A patient in this condition should be trephined in order to relieve pressure and to give exit to inflammatory products. It gives some hope of recovery, and the usually adopted medical treatment is practically useless. Should the patient recover, he must be guarded for a long time from physical exertion, mental excitement, worry, irritation, constipation, and insomnia.

Chronic Leptomeningitis (*or Chronic Encephalitis*).—The causes of chronic leptomeningitis are the same as those of the acute form. If traumatism is the cause, the inflammation arises at a later period than it would in acute encephalitis. The **symptoms** of concussion follow a head-injury. Days, or even weeks, after the accident, a series of symptoms occur—namely: localized pain at the seat of injury, often accentuated by tapping; listlessness; irritability; apathy regarding business affairs and home obligations, or profound depression and hypochondria with inability to attend to business. Choked disc may exist. In any case acute encephalitis may arise, with or without a chill. The **treatment** of this disease is symptomatic unless local symptoms exist. Always operate if localizing symptoms are found. Intense local pain justifies trephining.

Tuberculous Meningitis (Acute Hydrocephalus; Water on the Brain).—This inflammatory condition is due to the bacilli of tuberculosis. In a child affected with tuberculous meningitis there is often a record of a fall, the injury acting as an exciting cause by establishing an area of least resistance. Prodromal symptoms are common (restlessness, irritability, anorexia, change of character). The disease begins with a convulsion or with headache, fever, and vomiting, the child cries out from pain (*the hydrencephalic cry*), and the bowels are constipated. The pulse is rapid in the beginning, but later becomes slow and irregular. The pupils are contracted, there is muscular twitching, and the sleep is impaired. The temperature is about 103°. In the second period of the disease the vomiting ceases, constipation becomes more marked, the belly retracts, headache is not so violent, and the patient lies in a soporose condition interspersed with episodes of delirium. In this stage the pupils dilate and are often unequal, the head is retracted, convulsions occur or limited rigidity is noted, the respirations are sighing, and if a finger-nail is drawn along the skin, a red line develops (the *tâche cerebrale*, due to vasomotor paresis). Squint and consequent double vision are usual. In the last stage coma becomes absolute and general convulsions or limited spasms are apt to occur. Optic neuritis exists, and the child passes to death along a road identical with that of typhoid collapse. In some cases the examination of cerebrospinal fluid withdrawn by lumbar puncture throws light upon the diagnosis. In children the base of the brain is usually involved, and the disease is apt to last from two to four weeks; in adults the convexity is usually involved, and death is apt to occur in a few days.

The **treatment** is like that for traumatic meningitis. Operation seldom offers any chance of improvement, and never does unless the process is limited in area and confined to the convexity. Lumbar puncture is usually performed but for diagnostic rather than for therapeutic reasons.

Abscess of the brain is a localized collection of pus. The organisms found are noted upon page 716 (Acute Leptomeningitis). The **causes** are suppurative otitis media (in half of all the cases), fracture of the skull, concussion or wound of the brain, and general septic diseases. A tuberculous mass may caseate (tuberculous abscess). The abscess may be between the dura and skull (extradural), adhesions forming and preventing a general leptomeningitis, between the dura and brain (subdural), or in the brain-substance (cerebral or cerebellar). Leptomeningitis may arise because no adhesions are created, because septic clots form in veins or sinuses, or because infected blood regurgitates into the sinuses (Park). A traumatic abscess is generally beneath the area to which the traumatism was applied, but it may be on the opposite side. The infection may begin in the nose, the orbit, or the middle ear (page 716). Roswell Park says infection may pass along blood-vessels, lymph-vessels, nerve-sheaths, or the prolongations of the membranes which extend outside of the skull. An acute inflammation of the middle ear rarely causes abscess, because an acute inflammation in sound tissue causes the formation of granulation tissue, which acts as a barrier to infection. Chronic inflammation of the middle ear is the most frequent cause of abscess. Park tells us that if the roof of the tympanum is involved, it may perforate and abscess of the middle fossa may form; if the tympanum

is perforated toward the mastoid antrum, the abscess arises in the temporo-sphenoidal lobe; if the perforation is toward the sigmoid groove, the abscess forms in the cerebellum.*

Symptoms of Abscess of the Cerebral Substance or of the Cerebellum.—The symptoms due to pus-formation are as follows: There is an initial rise of temperature, but (except in extradural abscess) the temperature may quickly become normal or even subnormal. Subnormal temperature is not nearly so common as is usually supposed. It has been present in about one-half of the cases I have seen. Toward the end of the case the temperature may rise and the fever becomes linked with delirium. Surface elevation of temperature over the seat of the abscess is occasionally observed. A chill may occur, but seldom does. Anorexia and vomiting are present. Urinary chlorids are diminished and the phosphates are increased (Somerville). Certain symptoms are due to pressure: Headache begins (which at first is general, then local, and grows worse later in the case, and exists even in delirium; this fact distinguishes it from the headache of fever, which ceases in delirium); pulse is very slow; respiration tends to the Cheyne-Stokes type; drowsiness lapses into stupor and stupor passes into coma; paralysis of the sphincters takes place; convulsions are common; sensation is rarely impaired; and paralysis of the basal nerves may occur (third and sixth especially). The pupil on the same side as the abscess is sometimes dilated and fixed. Choked disc is not invariably found; if it is unilateral, it is on the same side as the abscess; if it is bilateral, it is more marked on the same side as the abscess. Localizing symptoms, spasmodic and paralytic, depend upon the center which is irritated or destroyed. In cerebellar abscess there are vertigo, vomiting, occipital headache, rigidity of the post-cervical muscles, and incoördination, but choked disc may be present or absent.

Meningitis arises soon after an accident; an *abscess*, more than a week, and often many weeks, after an accident. Meningitis presents high temperature and the general symptoms before outlined. *Mastoid disease* may occasion cerebral symptoms without abscess, or it may cause abscess. In *sinus-thrombosis* there is septic temperature, the veins of the face and neck are enlarged, and a clot can usually be felt in the jugular. A *tumor* grows slowly, usually presents almost from the start localizing symptoms, and double choked disc is frequently present. In tumor the temperature is apt to be normal.

Treatment.—If abscess is due to ear disease with implication of the mastoid cells, at once open and clean out the mastoid (Fig. 416), and after this proceed to trephine the skull in order to reach the abscess. In any case, if symptoms of abscess exist, trephine the skull at once. If localizing symptoms are present, open over the suspected region. If localizing symptoms are not present and the cause is ear disease, trephine at Barker's point (Fig. 416). If no pus is found between the bone and dura, open the membrane. When the dura is opened, if the abscess is subdural, pus will be evacuated; if the abscess is in the brain-substance, the brain will bulge very much and will not be seen to pulsate. A grooved director is plunged into the brain, in the direction of the abscess, for two or two and a half inches (Keen). If pus is not found, withdraw the director and introduce it at another point. When pus is discovered, incise the brain with a knife, enlarge the opening by inserting a

* Park, in Chicago Med. Record, Feb., 1895.

closed pair of forceps and withdrawing the instrument with the blades open. Scrape away the granulation tissue lining the abscess-cavity, irrigate with hot salt solution, and introduce a rubber drainage-tube and suture it to the scalp; stitch the dura, but leave an ample opening for the tube; bring the tube out through a button-hole in the scalp, and after the first two days pull the tube out a little every day and cut off a piece. If the first trephining does not find pus, trephine again at another point. In cerebellar abscess make a flap with the base up, and trephine or gouge away the bone just below the line of the lateral sinus. Puncture the brain as for cerebral abscess.

Brain Disease from Suppurative Ear Disease.—Chronic disease of the middle ear is apt to destroy the bone between the tympanum and the middle fossa of the skull, and thus produce meningitis, thrombosis of the petrosal or lateral sinuses, abscess of the temporo-sphenoidal lobe or of the cerebellum, or extradural abscess. Chronic otitis media also induces inflammation or suppuration of the mastoid cells (*empyema of the mastoid*). Pus in the mastoid may discharge itself into the middle ear, and from this point into the external auditory canal, through a perforation in the drum-membrane (especially in acute cases). In some cases the pus becomes blocked up within the mastoid process. Pus in the mastoid may after a time break into the cavity of the cranium or into the lateral sinus, or may find its way externally and open into the sheaths of muscles arising from the mastoid. It not unusually opens into the sheath of the digastric muscle (*Bezold's abscess*). These facts teach the surgeon that chronic ear disease should never be neglected, but should, if possible, receive the closest attention of the specialist. If no perforation exists in the drum, the surgeon must make one. In ordinary cases cleanliness and antisepsis are sufficient, the ear being syringed every day with a warm 2 per cent. solution of common salt. If only a small drum-perforation exists, 10 drops of pure alcohol or of corrosive sublimate solution (1 : 5000) are dropped into the ear daily; but if a large drum-perforation exists, boric acid and iodoform (7 to 1) are insufflated. Never inject alum. A strong silver solution is not safe; if it is used, wash the ear out afterward with warm salt water. If granulations or polypi exist, they must be removed. Some cases require the removal of the drum-membrane and the ossicles of the ear. Many cases of mastoid necrosis are due to tuberculosis. If headache, vomiting, and mastoid tenderness exist, open the mastoid (see page 739), in order to prevent abscess of the brain. In acute otitis media it is very rarely necessary to open the mastoid. The middle ear is on a lower level than the antrum of the mastoid, and in most acute cases both the middle ear and mastoid cells drain safely through a drum-perforation. Because a man has chronic otitis media it is by no means always necessary to trephine the mastoid. In many cases removal of the ossicles and drum-membrane effects a cure. In chronic otitis media, even if the mastoid is trephined, the ossicles and membrane ought to be removed.

Cerebral abscess from ear disease is almost always in the temporo-sphenoidal lobe, but may arise in the cerebellum. The **symptoms** are a transien trise of temperature, followed in many cases by a normal or subnormal temperature; vomiting; mastoid, frontal, and temporal pain. The mind is dull, and stupor arises which passes into coma; the bowels are constipated; choked disc may be present; and convulsions or spasms or paralyses may exist.

Trephine and clean out the mastoid, and asepticize (see Operations upon the Skull and Brain). Also trephine at Barker's point, one and one-fourth inches behind, and the same distance above, the middle of the external auditory meatus, open the dura, and seek for pus. If pus is not found, open the cerebellum.

Extradural Abscess.—The eye-symptoms and pain are the same in this as in cerebral or subdural abscess, but the temperature is different, rising to 103° or 104° F. There is often considerable tenderness above and behind the mastoid. In extradural abscess following disease of the middle ear trephine and clean out the mastoid; follow up a bone-sinus to the abscess, rongeur away the bone, being careful to avoid injuring the lateral sinus; curet, irrigate, and drain.

Infective Sinus-thrombosis.—Any sinus may be attacked. The disease may result from scarlet fever, smallpox, diphtheria, influenza, typhoid, or any acute suppuration. In erysipelas of the scalp, septic clots may form in the veins which pass through the bone and reach the longitudinal sinus. Infective thrombosis of the superior longitudinal sinus is thus produced.

In carbuncle of the lip and orbital suppuration the cavernous sinus may become involved.

In caries of the basilar portion of the occipital bone the circular sinus or the cavernous sinus may suffer. In caries of the petrous portion of the temporal bone, and in suppuration of the middle ear and mastoid process, infective thrombosis of the lateral sinus may occur.

In any case the symptoms are those of pyemia. The lateral sinus is the one most frequently attacked. In infective thrombosis of the lateral sinus there is usually a history of an old discharge from the ear.

Infective thrombosis of the lateral sinus may result from a specific fever, but is usually due to chronic suppuration of the middle ear associated in most cases with carious bone and pus in the mastoid process. Thrombosis of the lateral sinus occasionally follows an operation upon a suppurating mastoid, or develops in an individual who suffers from middle-ear disease who has been struck upon the head, who has had the ear syringed with force, or who has had injected a corrosive or very irritant fluid. Tuberculous bone disease is an occasional cause.

Symptoms.—In most cases there is a history of chronic ear disease. In children the symptoms are more acute than in adults. In any case the symptoms may rapidly become violent. In some cases there are preliminary symptoms of extradural abscess, pus being lodged in the groove of the sinus. It has been pointed out that pus in the jugular foramen may make pressure upon the pneumogastric, spinal accessory, and glossopharyngeal nerves, producing aphonia, hoarseness, dyspnea, dysphagia, and slow pulse (Geo. F. Cott *). Marked headache ushers in sinus-thrombosis. The pain is apt to be localized about the ear and mastoid process, but may become general. There is usually tenderness of the mastoid. There is high fever from the start, but when the clot begins to soften and break down, hard rigors develop and the temperature fluctuates violently. The temperature varies each day between subnormal and 106° to 107°. A chill may occur once or even twice a day, and it lasts from ten to twenty minutes. The pulse is soft and usually rapid. The patient is nauseated, labors under vertigo, is very restless,

* Am. Med., April 19, 1902.

is sometimes delirious, may become dull and stupid, and the muscles of the neck are stiff. Tenderness and marked edema are detected over the mastoid, and the veins of the neck and mastoid region may be enlarged. When the clot extends into the jugular vein there is pain on moving the head and on swallowing, the cervical glands are swollen, and a clot may be felt in the neck. Choked disc exists in about half of all cases. There is often a profuse discharge of pus from the ear, but in some cases the discharge is found to have abated or ceased. Exophthalmos and swelling of the eyelids point to involvement of the cavernous sinus in the process. In early cases there is thrombosis of the lateral sinus alone, or of the lateral sinus and jugular vein. The internal jugular vein may be felt as a cord in the neck. In advanced cases other sinuses become involved (superior petrosal, inferior petrosal, both cavernous, the lateral sinus of the opposite side, the ophthalmic veins, and the torcular Herophili). A patient with sinus-thrombosis is in great danger of developing pulmonary metastasis and septic meningitis (Jansen). Septic meningitis is accompanied by abscess about the sinus. Infective sinus-thrombosis is a very fatal disease and usually runs its course in from seven to ten days, but occasionally lasts for weeks. It is a form of pyemia, and death arises from the causes which have been referred to in discussing that disease.

Infective thrombosis of the cavernous sinus causes the general symptoms of pyemia and also edema of the lids, and exophthalmos.

Infective thrombosis of the petrosal sinus produces pyemic symptoms but no characteristic signs.

The **prognosis** largely depends upon early recognition. The surgeon should, whenever it is possible, open a mastoid before sinus-thrombosis arises, and should evacuate an abscess about the sinus before a clot forms in the venous channel, or at least before that clot becomes septic (Jansen).

Treatment.—In 1880 Zaufal proposed the operation now practised, and Horsley first did it in 1886. (See article by Geo. F. Cott, in "American Medicine," April 19, 1902.) Infective thrombosis of the lateral sinus is treated as follows: Open and clean out the mastoid, and expose the sinus by the use of the chisel or rongeur (Fig. 416). Follow M. Ballance's advice and expose the sinus from the bulb to the torcular. The jugular vein should now be exposed at the level of the cricoid cartilage and ligated below any clot which may exist. This is done to prevent propagation of an infected clot and diffusion of sepsis. Even if a clot does not exist in the jugular, the vein should be tied in two places and divided, because the sinus may contain infected clot or putrid material even when the vein as yet does not. According to Ballance, the portion of the vein above the point at which it was divided should be extirpated. Some surgeons after ligating the jugular do not excise it, but if it contains or comes to contain a septic clot, incise the vein up to the base of the skull and pack the wound. After attacking the vein open the sinus, and if a clot is found to exist, cut away the wall of the sinus. Introduce a small spoon into the lumen and carry it toward the torcular Herophili, and scrape away the clot until blood flows. Arrest hemorrhage by plugging a piece of iodoform gauze into the wound and toward the torcular. Jansen opposes removing the entire clot toward the jugular, and does not tie the jugular, believing that to do so increases the danger of thrombosis of the inferior petrosal and cavernous sinuses. He simply removes the soft clot, but does

not disturb the solid clot toward the heart. Most surgeons differ from him. Surgeons are of the opinion that it is futile to do any operation if pulmonary metastasis has taken place. In a recent case of the author's in the Jefferson Medical College Hospital the patient recovered after operation in spite of the fact that endocarditis had developed.

Until recently it was thought that the lateral sinus was the only sinus which should be attacked surgically, but in one case Knapp, of New York, requested Hartley to remove from the cavernous sinus a clot which was causing blindness and was due to sarcoma. The operation was successfully executed by Hartley, the incision being the same as is employed to reach a Gasserian ganglion in the Hartley operation. This patient lived several months. Dwight operated upon another case by incision of the sinus (E. W. Dwight and H. H. Germain, "Boston Med. and Surg. Jour.," May 1, 1902). Some surgeons advise removal of the eyeball and curetment of the sinus.

Intracranial Tumors.—An encephalic tumor may originate within the skull. It may have arisen from an external growth invading the cranial cavity, or may be metastatic. A tumor that arises within the cranium may take origin from the periosteum, from one of the membranes of the brain, from the vessels, from the neuroglia, or from the brain-substance.

No region of the body is so liable to tumors as the brain. During the course of a number of years the autopsies of the Munich Pathological Institute are stated by Bollinger to have shown one tumor of the brain in every 85 autopsies. Hale White's experience is that such tumors are even more common than this, and he estimates them at one in every 59 autopsies.

In endeavoring to determine the causes of intracranial tumors we must accredit heredity with considerable influence in tuberculoma, and possibly with some force in sarcoma and carcinoma. Tumors of the brain are decidedly more common in males than in females, probably because of the greater male liability to injury, syphilis, and alcoholism.

The majority of cases of tumor of the brain occur between the ages of twenty-five and fifty. Children are particularly prone to suffer from glioma and from tuberculous growths. In aged persons a tumor of the brain very rarely develops. In 100 cases of brain-tumor collected by Hale White only 2 were aged seventy or over. In 100 cases collected by Mills and Lloyd only 1 was over seventy.

Injury may be responsible for the development of sarcoma, of fibroma, and possibly of other forms; in fact, a syphiloma may arise in a syphilitic person at the seat of an injury.

We use the term intracranial or encephalic tumor not only to include true neoplasms, but also to designate growths of parasitic, syphilitic, or tuberculous origin. It is of importance to attempt to make a diagnosis as to the form of tumor that is present, and this may be possible on account of the fact that in many cases the form affects the symptoms. A useful classification of these growths has been made by Knapp, and is as follows: (1) The infective granulomata, including tuberculous growths, gummata, and actinomycotic areas; (2) connective-tissue growths; (3) epithelial growths; (4) aneurysms. The most common of all these tumors is undoubtedly that due to tubercle. In fact, Gowers estimates that if we exclude syphiloma,

tubercle is responsible for one-half of the cases, and glioma and sarcoma together for one-third.

Tuberculous Tumors (Tuberculous Gummata; Tuberculomata).—Tuberculous tumors are the most common form met with. They are at least four times as common in children as in adults. They may be single, especially in adults, but are often multiple, especially in children; and multiple growths may be very wide-spread. According to Allan Starr, these growths are most common in the cerebral axis (especially in the basal ganglia), next in the cerebellum, next in the cerebral cortex, and are least common in the centrum ovale. A tuberculous tumor usually arises in the pia mater, particularly in an arterial distribution, but may begin in a ventricle, or even in the brain-substance. Some of these growths are distinctly subcortical. The tubercle bacilli responsible for the condition are carried by the blood. A large tuberculous tumor is due to the coalescence of many foci. It undergoes caseation in the center, and is surrounded by a zone of softened or sclerotic brain-substance. Tuberculous meningitis is present in two-thirds or three-fourths of the cases of tuberculoma.

Gummatous Tumors (Syphilomata).—We find a single gumma, but, far more often, syphilitic growths are multiple. Such a growth may be round, or may be irregular in outline; in fact, the outline is frequently blurred and indistinct. Some of these growths are soft, and some, which contain a quantity of connective tissue, are hard. A syphiloma usually arises from the membranes, and, hence, is generally on the surface of the brain; and the membranes in the region of the growth usually show distinct inflammation.

Actinomycosis.—This is a very rare condition, in which the mass may remain solid like a tumor, but is far more apt to break down into an actinomycotic abscess.

Sarcomata.—Injury seems to play a considerable part in the production of intracranial sarcoma. Any variety of sarcoma may arise. As a rule, at least in the beginning, the growth is single; but it may be multiple, or may become so. The majority of sarcomata arise from the membranes or from the periosteum, but some cases take origin from beneath the cortex. Early in their progress these growths may be encapsulated, but some of them, from the very start, are infiltrating; and even those that were at first encapsulated later infiltrate. *Endothelioma* is sometimes met with. What is called *angioma of the brain* is, in reality, *angiosarcoma.* A *psammoma* is usually sarcomatous.

Gliomata.—A glioma is a growth so ill defined and so slightly differentiated in appearance from the brain-substance that it may easily be overlooked in an exploratory operation. It arises much more frequently from the white than from the gray matter, and develops from the neuroglia of the cerebrum, of the cerebellum, of the pons, or of the medulla oblongata. A glioma may be soft or may be hard; and soft gliomata are probably, in reality, sarcomata. Hemorrhage is very apt to occur in these growths.

Fibromata.—Intracranial fibroma is a rare growth. It is of firm consistence, is encapsulated, and may grow to a large size. Such growths can be readily enucleated. Injury seems occasionally to be responsible for their formation.

Osteomata.—Osteophytic growths not uncommonly take origin from the

inner surface of the skull, but the osteomata arising in the dura or in the brain-substance are rare. Such growths, however, occasionally occur.

Cholesteatomata.—These tumors are fibrous growths covered with endothelium and containing layers of cholesterin. They are particularly apt to arise in the pia mater, but may begin in either of the other membranes or in the brain-substance. A cholesteatoma is commonly called a *pearl tumor.*

Enchondromata and *true neuromata* are rare, and *lipomata* are exceedingly uncommon.

Adenomata.—An adenoma occasionally springs from the conarium, or the pituitary body.

Carcinomata.—Primary intracerebral carcinoma is rare, but does occur. Secondary carcinoma is more common, and may follow cancer of any part of the body, although it is most apt to follow cancerous growths about the face and neck. A primary growth may begin in the meninges or in the lining of the ventricle. Intracerebral carcinomata may be single or multiple. They are soft and non-encapsulated growths.

Cysts.—Mills says that cysts arise about an old hemorrhage, are small retention-cysts of a vascular plexus, or are porencephalic. Dermoid cysts are extremely rare.

Symptoms.—The symptoms are diffuse and local, and are similar in many particulars to the symptoms of some other lesions. Among the symptoms of tumor are headache, slow speech, stupor or coma, slow pulse, pain on percussion of the cranium, vertigo, vomiting, epileptic convulsions, double choked disc, partial or complete blindness, extensive or limited paralyses, paralysis of the face, the eye-muscles, or the limbs, zones of anesthesia and aphasia, word-deafness, word-blindness, agraphia, incoördination, and mental disturbances. The situation of a tumor is determined from localizing symptoms, their mode of onset and manner of combination. In some cases the symptoms are not characteristic, and in some cases there are no localizing symptoms. The more marked the signs of compression, the less the value of localizing symptoms. The nature of the tumor, its depth, and whether it is single, and if other tumors exist, is, if possible, determined. Localizing symptoms may be due to irritation or destruction of functionating power. Irritation causes spasm, and destruction induces paralysis. Convulsions which are local or which begin locally are known as *Jacksonian epilepsy.* A local convulsion points to an irritative lesion of, or immediately adjacent to, the center which presides over the muscular movements of the part convulsed. Local paralysis points to a destructive lesion of the center which presides over the movements of the paralyzed part. In some cases a center is damaged and the muscular movements it controls are paralyzed, but the adjacent brain-areas are irritated and the muscles they represent are attacked with spasms. In some cases an apparently paralyzed part becomes convulsed, the center not being completely destroyed and sudden hyperemia serving to awaken spasm. Always note the order of invasion of different regions and observe if spasm is followed by muscular weakness or anesthesia. In every case of suspected tumor an x-ray picture should be taken, and in some cases it will show the growth.

1. Lesions in the Cortical Motor Area.—An irritative lesion of the lower third of this area causes spasm of the opposite side of the face, angle

of mouth, or tongue; and this condition is often associated with tingling (Osler). The spasm may remain limited or may extend widely, and may even become general. Tumors of the third frontal convolution of the left side cause *motor aphasia*. An irritative lesion of the middle third of the cortical area causes spasm, which is limited to or begins in the fingers, thumb, wrist, or shoulder (Osler). An irritative lesion of the upper third of the cortical motor area causes spasm, which is limited to or begins in the toes, ankle, leg, or hip. If such lesions exist, an aura is occasionally felt in the affected region before the spasm begins, and there is often numbness after the spasm. Destructive lesions of the motor area cause local paralysis, which may be preceded by local spasm of the same parts, and is often associated with local spasm of other parts.

2. **Tumors of the prefrontal region** give no localizing symptoms, but produce general symptoms. Mental disorders are apt to occur. The intelligence is nearly always impaired. As the tumor grows it may subsequently involve the motor region, which in all probability lies entirely in front of the fissure of Rolando (Sherrington. Mills).

3. **Tumors of the parieto-occipital lobe** may occupy a silent region of this lobe. The centers for general sensibility and for the muscular sense are back of the fissure of Rolando in the parietal lobes. Hence a tumor in this region may cause disturbance of muscular sense and general sensibility in the limbs without spasm or palsy (Durante). There may be blindness when the angular gyrus is affected.

4. **Tumors of the occipital lobe** produce *homonymous hemianopsia*.

5. **Tumors of the temporosphenoidal lobe** frequently produce no symptoms. In the temporal lobes the cortical centers for hearing are placed, and each center is connected with both auditory nerves, but the crossed auditory bundle is larger and more active than the direct (Francesco Durante, "Brit. Med. Jour.," Dec. 13, 1902). Tumors in the left lobe are particularly apt to cause deafness and may cause *word-deafness*.

6. **Tumors** of any size in or about the **corpus striatum** cause hemiplegia by pressure upon the internal capsule. Pressure upon the optic thalamus produces hemianopsia and hemianesthesia. Growths near the basal ganglia produce intense optic neuritis and early pressure because of distention of the ventricles. Osler tells us that tumors of the corpora quadrigemina are apt to involve the crura, and later the third nerve. Ocular symptoms are always present (loss of pupillary reflex and nystagmus). If the third nerve is involved, there are paralysis of the motor oculi area on the side of the lesion (external strabismus, dilated pupil, and drop-lid) and hemiplegia of the opposite side of the body from pressure upon the crus. This condition is a form of *crossed paralysis*.

7. **Tumors of the Pons.**—Pontine lesions produce symptoms by pressure upon the particular nerves which come from this region, with or without the evidences of pressure upon the motor path. Forms of crossed paralysis may exist. Lesions in the lower half of the pons may affect the fifth, sixth, and seventh nerves on the side of the lesion and the limbs on the opposite side. The auditory nerve may be involved in the lesion. In crossed paralysis the face on the side of the limb paralyzed is usually not affected, but in extensive tumors it may be paralyzed. *Conjugate deviation* of the eyes may

occur *away* from the *facial paralysis*. In tumors of the upper part of the pons the pupils may be first contracted from irritation of the third nerve nuclei, and later dilated from destruction of these nuclei. Anesthesia as a result of pontine tumors is not nearly so common as is motor paralysis, and convulsions are rare.

8. Tumors of the Medulla.—An extensive lesion inevitably causes death. Cranial nerves only may be involved, but crossed paralysis may take place. Vomiting is common, retraction of the head is not unusual; respiratory and circulatory disturbances and dysphagia are frequently noted; sometimes there is numbness, and occasionally there are convulsions; usually there is incoördination, because of pressure upon the cerebellum.

9. Tumors of the Cerebellum.—In general it may be said that tumors of the cerebellum cause headache, vomiting, vertigo, choked disc, and early blindness. *Tumors of the middle peduncle* cause sudden uncontrollable movements of the trunk, either toward the side of the tumor or away from it. Vertigo and nystagmus are common. Symptoms are frequently complicated by evidences of pontine disease proper.

Tumors of the middle lobe of the cerebellum cause a sense of lost equilibrium and obvious unsteadiness in attempting to walk, or even to stand (Gowers). The patient has a tendency to fall; there are giddiness and vomiting.

Tumors of the cerebellar hemisphere produce no localizing symptoms. The usual unsteadiness of gait is due to pressure upon the middle lobe (Nothnagel).*

Treatment.—If any doubt exists as to the nature of a brain-tumor, give the patient a course of iodid of potassium, and as doubt is the rule, we almost invariably administer it. Give the drug at first in small amounts, but rapidly increase it until heroic doses are taken (100 or more grains a day). Mercury should also be given hypodermatically or by inunction. If iodid of potassium and mercury relieve the symptoms, operation is unnecessary, although it may be demanded later in order to remove an irritant scar. If antisyphilitic treatment fails, the question of operation must be considered. The term *operable case* does not of necessity mean a tumor which can be entirely removed by operation. Some tumors which can be only partially removed should be operated upon. An operable case is one in which an attempt may be made to remove the tumor and in which the tumor can be entirely removed or in which a part can be removed, the removal of this part promising relief. We are justified in being radical because without operation a brain-tumor is a certainly fatal malady. In many cases of undoubted tumor excision for cure is not attempted because of the absence of localizing symptoms or because of the inaccessible situation of the growth. In all cases operation is first of all exploratory. Tumors of the dura which have not infiltrated the brain, many cortical and some subcortical growths are operable. Cerebral cysts if accessible should be opened and drained in hope that benefit will result. Some subtentorial tumors can be removed. In certain cases it is justifiable to attempt the removal of a glioma if the growth is in an acces-

* For full consideration of localizing symptoms see the works of Gowers, Mills, Dercum, and Osler, which have been freely used in writing the above section.

sible region. Byrom Bramwell maintains that tumors at the base, tumors of the pons and medulla, of the corpus callosum, of the basal ganglia, and of the deeper parts of the centrum ovale, are irremovable. Most tumors at the base are inoperable, but some few are operable. Surgeons now regard some tumors of the cerebello-pontine angle as operable, but agree with Bramwell's views as to growths in the other situations he mentions. Frazier has concluded that "if the tumor is found to be very vascular and of the infiltrating type, it is very questionable . . . as to whether any attempt whatsoever should be made to extirpate" ("Univer. of Penn. Med. Bulletin," April–May, 1906), and with this opinion I certainly agree. In tumors which are very extensive complete removal is usually out of the question. There is no use in removing secondary malignant tumors. It often happens that the brain itself (as in syphilis) is so extensively diseased, or that other organs (as in tuberculosis) are so involved, as to render attempts at removal of the tumor futile or actual removal useless. Mills thinks that 50 per cent. of cerebellar tumors can be attacked surgically ("New York and Phila. Med. Jour.," Feb. 11–18, 1905). He classifies operable tumors of the cerebellum as follows: 1. Tumors situated entirely or chiefly in the lateral lobe. 2. Tumors upon or even invading a part of the vermis or middle lobe. 3. Tumors of the cerebello-oblongatopontile angle. Among inoperable tumors are most gliomata and infiltrating sarcomata, metastatic tumors, and multiple tumors. Bramwell tells us* that he has studied eighty-two cases of intracranial tumor, and he considers that in only five of them could the tumor have been entirely removed. In 157 reported cases the tumor was either not found or not removed; in 104 reported cases the tumor was found, and in some of them it was removed (Ransohoff, in "Jour. Am. Med. Assoc.," Oct. 11, 1902). The conclusion is that though some tumors of the brain may be successfully removed, extirpation is feasible in only a small minority of cases and is to be decided on only after careful study of all the indications and contraindications offered by the case. When an operation is decided upon, some surgeons apply an apparatus to the arm and the blood-pressure is taken just before the operation and at frequent intervals during it. Thus by noting a great fall in blood-pressure they get early warning of dangerous shock, learn when to hasten, and if the operation should be temporarily abandoned and be completed at another time (**two-stage operation**). We may be driven to abandon operation after cutting the bone and dural flaps, and if we are forced to stop, we restore the bone and dura to position, and complete the operation after a day or two. I agree with Frazier that the lessening of hemorrhage by temporarily clamping the carotids in the neck is not free from danger, and it is not proper to do more than apply Crile's clamp to the vessel on the side operated upon. In a brain-tumor when the dura is first opened there is usually at once marked bulging of the brain, which is called "*initial bulging*"; after working for a time on a brain, even when there is no tumor, bulging occurs from traumatic edema, which is called "*consecutive bulging.*" That consecutive bulging may occur is a sound reason for operating rapidly (Frazier). The mortality from tumor operations is large, death being due to shock and hemorrhage. Haas collected 122 cases in which the tumor was removed; the mortality was 60 per cent. Operations completed at one séance give a larger mortality than two-

*Edinburgh Med. Jour., June, 1894.

stage operations. During the operation an erect posture causes the brain to recede and permits of extensive exploration under the dura (Ransohoff and Cushing). The same thing is accomplished by lumbar puncture (Cushing). The fibromata constitute the best cases for operation. In operating on a cerebral tumor make a large osteoplastic flap. If on opening the dura the tumor is not visible, and if the localizing symptoms were reasonably positive, the surgeon is justified in making an exploratory incision through the cortex to see if there is a subcortical growth. Operations for cerebellar tumors are peculiarly difficult because of the large blood sinuses, because of the limited space obtained to work through, because of the great bulging after the dura has been opened, because of the impossibility of reaching the anterior, mesial, or upper surfaces through the incision, because of the liability to injure the pons and medulla, and because of the difficulty of retracting the parts (Frazier, in "New York and Phila. Med. Jour.," Feb. 11–18, 1905). In tumors which are not within a cerebellar hemisphere it is usually best to remove a considerable portion of the hemisphere in order to obtain free access to the growth. The diagnosis of cerebellar tumor is usually doubtful, hence practically all operations are at first exploratory and are then made palliative or radical as the case demands. Operation must be early because cerebellar growths quickly cause blindness. Though thorough extirpation is feasible in but few cases of brain-tumor, operation should often be performed for palliative purposes. Grainger Stewart, Annandale, Horsley, Macewen, Cushing, and Keen have advocated *palliative trephining* in certain cases. If this is done, a portion of dura must be cut away and hernia cerebri follows. Cushing has had some cases of extraordinary improvement after trephining in the right temporal region and removing a piece of the dura. This is called by him a *decompression operation.* The brain bulges through the dural opening, but the dense temporal fascia stitched together over it prevents fungation. It is the temporo-sphenoidal lobe that bulges, and the right side is selected because word-deafness might ensue if the operation were done on the left side. I have seen several of Cushing's cases. One of them, a colored man, had been almost blind for some time and was unconscious and had rapidly failing respiration when the operation was performed. He was so much benefited that he returned to work and has useful vision and no pain.

This procedure is of value in diminishing excessive intracranial pressure, and thus relieving headache and decreasing the tendency to sudden death from inhibition of the heart or respiratory failure (Hughlings Jackson and Byrom Bramwell).

Palliative trephining may relieve choked disc, and thus retard or prevent atrophy and blindness. Bramwell asserts this positively, and he believes that excessive intracerebral pressure is an important element, though not the only element, in choked disc. Cushing seems to demonstrate that it is the chief element.

We conclude that most cases of brain-tumor should be trephined for exploration; in some cases extirpation may be performed; in most cases extirpation is impossible, and the surgeon must be content with the palliative influence of Cushing's decompression operation. A tumor of the brain if not cured by antisyphilitic treatment is of necessity fatal if unoperated upon, and exploratory trephining is not a very dangerous operation.

In a case of brain-tumor if operation is refused, if extirpation is impossible, or if decompression fails, it may be necessary to use the bromids for convulsions and morphin for headache. The headache is often benefited by purgatives, courses of potassium iodid, the ice-bag to the head, and the application of a hot iron to the nape of the neck.

Operative Treatment of Epilepsy.—The shock of an accident or a cerebral concussion may establish epilepsy, especially in those predisposed by heredity or other causes. Traumatic epilepsy, Le Dentu tells us,* may be due to: (1) Bone-fragments from skull-fracture; (2) outgrowths of bone due to tumor; (3) cicatrices of meninges resulting from laceration of membranes by bone-fragments; (4) chronic meningitis which ends in sclerosis of membranes; (5) cysts resulting from intracranial hemorrhage at the point of fracture; (6) arteriovenous aneurysm. We would add: (7) tumors of the brain; (8) sclerosis of the cortex. We refer here, in speaking of traumatic epilepsy, purely to the condition when it follows a head-injury, and this is the common meaning of the term. Remember that epilepsy, as shown by Sachs, may follow a long-forgotten injury. Before undertaking a brain operation for epilepsy it is a sound rule to remove all sources of definite peripheral irritation. I have seen apparent cure follow the removal of a tender cicatrix and follow circumcision of a patient laboring under phimosis. Briggs reported a case of epilepsy in which there was a distinct depression of a portion of the skull. There was also necrosis of the tibia, and after the cure of the necrosis the convulsions ceased. The removal of supposed peripheral irritation, however, is beneficial only occasionally. Are operations upon the skull and brain curative? Surgeons are much less enthusiastic than they were a few years ago. I believe operation can cure less than 5 per cent. of cases, but it is important to remember that in some cases in which operation seems to have failed medical treatment becomes much more efficient than it was before the operation. The high rate of cure (70 per cent.) once claimed for operations was due to failing to follow the patient sufficiently long. A patient should not be reported as cured until at least three years, and better, five years, have passed without any evidence of the disease. Another source of error was a failure to understand that any traumatism may improve epilepsy *for a time.* "The administering of an anesthetic, the shock of an injury, the traumatism of an operation, just like a febrile seizure, may interrupt an epileptic habit and cause a patient to go for weeks or months without an attack" (the author, in "Medicine," Feb., 1904).

Operation must never be indiscriminately applied. In some cases it gives hope of relief, in others it is obvious that it would be utterly futile. In order to determine if a case is or is not suitable for operation it must be studied with great care. The history must be carefully obtained, particularly as to hereditary predisposition, the first convulsion, and its *supposed* cause. The question of injury, recent or old, should be thoroughly investigated, and it is a sound rule to have the head shaved and then examine for a scar and for a depression. Convulsive seizures must be studied by an expert, hence the patient should be in a hospital, constantly watched by a trained nurse, until one or two fits have occurred. The nurse watches the convulsion and describes it in writing, noting particularly if it had a local beginning. The general health must be investigated.

*La Presse médicale, June 9, 1894.

I am accustomed, for surgical purposes, to make the following classification of epilepsy. It is a modification of Sir Victor Horsley's classification (the author, in "Medicine," Feb., 1904):

1. Reflex epilepsy, the surgical treatment of which I shall not discuss in detail.
2. The common non-traumatic, idiopathic, or essential epilepsy, in which the attacks are general and are without a local onset.
3. Idiopathic epilepsy with a local onset of attacks (focal or Jacksonian epilepsy).
4. Traumatic epilepsy. This may be subdivided into two forms: (*a*) attacks without a local onset; and (*b*) attacks with a local onset (focal or Jacksonian epilepsy).
5. Jacksonian epilepsy due to gross brain disease (tumor, aneurysm, etc.).
6. Epilepsy following infantile cerebral palsy.
7. The posthemiplegic epilepsy of adults.

1. **Reflex Epilepsy.**—Remove the supposed cause of irritation. When epilepsy follows traumatism and a scar is found on the scalp, excise the scar. This is an imperative duty if the scar is tender or the seat of an aura.

2. **Essential or Idiopathic Epilepsy.**—Operation upon the brain is useless. If persistent headache exists, it is then proper to trephine and open the dura for exploration. Such an operation is done to relieve headache. Some claim remarkable results from bilateral excision of the cervical ganglia of the sympathetic (page 678). The operation is a theoretical one and of doubtful utility. It was founded upon a misconception as to the cause of epilepsy, and favorable reports are no more favorable than have been set forth regarding various other now abandoned procedures.

3. **Idiopathic Epilepsy with Local Onset of Attacks** (*Focal or Jacksonian Epilepsy*).—Many of these cases begin in young children who have had infantile palsy, the traces of the palsy having disappeared. In such cases the convulsions may begin on one side, and in fact may be nearly limited to one side. If, from the very beginning, the attacks began in one group of muscles or in one extremity, whether or not they spread to the rest of the body, and if the case is seen within two years of the first attack, the surgeon is justified in exposing the brain and excising the irritated portion of cortex. This operation, it is true, cures very few cases, but it benefits many for a considerable time and seems to make them more amenable to medical treatment. In the vast majority of cases fits recur, but rarely as severely as before. After fits have been going on for two years operation offers no prospect of cure, as the association fibers have surely degenerated. But, even in very old cases, if the attacks are frequently repeated and thus threaten life, the excited center should be removed to save life.

In cortical excision more of the cortex than the excited center is of necessity removed, because, in order to get the entire center, we must go wide of it. Paralysis of the parts controlled by the extirpated cortical area follows. The paralysis is seldom permanent except to the finer movements. The operation gives the best prognosis in young persons, and when done early in the case. The return of fits after apparent cure is thought to be due, at least in some cases, to the formation of *adhesions* between the brain and its membranes. Various unsatisfactory attempts have been made to prevent adhesion by the insertion of silver foil, gold foil, rubber tissue, egg-shell

membrane, and Cargile membrane. In operating for cortical epilepsy a large osteoplastic flap is required. In the previous remarks we dealt with partial epilepsy and with generalized epilepsy in which, from the first, the attacks had a local beginning. If cases of apparent idiopathic epilepsy develop Jacksonian attacks (attacks with a local beginning), it is useless to excise the cortex. The entire cortex is diseased, though one region is particularly unstable.

4. **Traumatic Epilepsy.**—Always remember that a traumatism to a person who becomes epileptic may have been only a coincidence; the condition may be essential epilepsy and the traumatism may have had nothing to do with it. Epilepsy ensuing upon traumatism may not begin until months or even several years after the injury. In the earliest attacks consciousness may or may not be lost. The causative injury may have been slight or severe. "An injury may cause a hemorrhage or a depressed fracture; may be followed by a scar upon the membranes; may occasionally lead to the development of an innocent or malignant tumor or a cyst, or may merely induce some trivial change in the subtle chemistry of the nerve-cells" (the author, in "Medicine," Feb., 1904). Injury may produce general epilepsy or Jacksonian epilepsy. If an identified traumatism exists, the surgeon should operate even after years. When the traumatism has not left definite evidence, the surgeon is justified in making an exploration any time up to the termination of the third year after the accident. The earlier the operation, the better the prognosis. The best prognosis of any form of epilepsy is given by Jacksonian epilepsy of traumatic origin.

"In focal epilepsy with evidences of skull injury or depression, trephining is imperative and somewhat promising. The dura should invariably be opened, even if it seems in good condition. A dural scar should be extirpated. The brain should be examined by sight and by touch, and should be explored with the little finger and with the dural separator to well beyond the limits of the opening in the dura. If a tumor is found, it should be removed; if a scar upon the brain exists, it should be extirpated; if a cyst is discovered, it should be drained; and if there is any obviously damaged area in the brain tissue, it should be unhesitatingly cleared away. If nothing obvious is found on exploration, and if the attacks have been distinctly focal in origin, it is justifiable to extirpate the motor center from which the discharge seems to originate.

"When Jacksonian epilepsy has followed an injury in the motor region, the chances of effecting a cure are much better than they are when the epilepsy has followed an injury in the sensory region. When it has followed an injury in the frontal region, operation affords very little hope of cure.

"When the condition is not focal but essential epilepsy, the surgeon will remove a scalp scar; and if there is any evidence of bone injury, he will trephine the bone, open the dura, and explore the brain. It is needless to say, however, that in such a case he will not extirpate any of the cortex.

"In cases of focal epilepsy I use the osteoplastic method of operating. In cases of generalized epilepsy I use the simple trephine and leave the button of bone out, as a means of effecting a prolonged modification in the intracerebral pressure" (the author, in "Medicine," Feb., 1904).

Bramwell maintains that when traumatism is followed by epilepsy and the epileptic discharge starts from a cortical center which is not beneath

the scar, the surgeon should trephine first at the seat of injury, and if this fails, he should trephine over the excited center.

5. **Jacksonian Epilepsy due to Gross Brain Disease.**—The treatment of this condition is the treatment of the brain disease.

6. **Epilepsy following Infantile Cerebral Palsy.**—In this group of cases the palsy is manifest. It is justifiable to operate upon a child but not later in life. The prospect of benefit is poor even in a child.

7. **The Post-hemiplegic Epilepsy of Adults.**—Operation is useless.

Our conclusions are that these operations sometimes seem to cure epilepsy, but so, occasionally, does any operation. White records* ninety trephinings in which, though no cause was found for the epilepsy, great relief followed, and two cases were apparently cured; he mentions benefit or apparent cure following tracheotomy, ligation of the carotid artery, incision of the scalp, etc. The same effect may be obtained by a great shock, high fever, the administration of an anesthetic, or an accident. The fact seems to be that any operation, by means of nervous shock, may interrupt the epileptic habit; but in ordinary operations the fits tend after a time to recur and soon reach their old standard of frequency. In the special brain-operations with removal of obvious lesions or extirpation of discharging centers the fits usually recur, but they will rarely reach the old standard of frequency, and will be more amenable to medical treatment.

In non-traumatic chronic epilepsy without localizing symptoms trephining is not justifiable unless persistent headache calls for it as a means of relief from intracranial pressure. Annandale has recently advised us to consider experimental operation in such cases when the drug-treatment has failed and when the patient's condition seems hopeless. He says there is no chance of improvement without operation, and operation may possibly disclose a removable lesion.† After trephining for epilepsy five years should elapse without a convulsion before cure is reasonably assured; and if convulsions arise, they must at once be met by medical treatment. A man having once had a convulsion may at any time have others; hence he should always be watched. It is not unusual for a few convulsions to occur soon after an operation for epilepsy, and then to cease for a considerable time. These early fits result from habit (*habit fits*). Among the operative procedures suggested for the treatment of epilepsy may be mentioned circumcision, clitoridectomy, ocular tenotomy, ligation of the vertebral arteries, removal of the cervical ganglia of the sympathetic (page 678) (Alexander, Jonnesco, Jaboulay), and the actual cautery to the head (Féré).

Operative Treatment of Insanity (see the author in "Journal of Nervous and Mental Diseases," June, 1904).

1. **Epileptic Insanity.**—The conditions which call for operation on a non-insane epileptic (page 730) call for it on an insane epileptic. It is sometimes justifiable to operate if there has been a head injury, and operation may lessen the number and diminish the violence of the attacks. If focal seizures exist, we may proceed as for focal seizures in the sane. In status epilepticus we may operate to relieve pressure. It will be observed that operation is for the convulsions and not for the insanity.

* "The Supposed Curative Effects of Operations *per se*," Annals of Surgery, Aug. and Sept., 1891.

† Edinburgh Med. Jour., April, 1894.

2. **Paresis.**—I do not advocate operation in paresis. If we believe in traumatic paresis, we may be inclined to advise operation. Personally I do not believe that genuine paresis is ever cured; the lesions of the disease are widely disseminated; the pons, medulla, and even the cord may be diseased and the lesions cannot be removed.

3. **Non-traumatic Insanity and Paranoia.**—Operation cannot cure the insanity and is not to be advised.

4. **Hypochondriacal Delusions.**—Operation is useless. Some practice it with the idea of getting rid of a delusion by removing a part to which the attention is directed. Such attempts always fail, because it is the insanity which causes the delusion, not the delusion which causes the insanity.

5. **Operations for Traumatic Insanity.**—A pyschosis constructed on the basis of a traumatic neurosis never calls for operation. The only cases in which operation is ever justifiable are those in which traumatism is the direct cause. Insanity may begin at once or soon after an injury, but is often unrecognized for weeks or even months. Nearly all of these cases are predisposed to insanity and the injury has been only an exciting cause. Traumatism is the direct cause in about 2 per cent. of cases of insanity.

"An antecedent injury may have directly induced the alienation; it may have had no bearing at all upon the latter; or it may have produced an insanity by fear and shock, and not by creating a direct brain lesion. Again, the head injury, by increasing the individual's susceptibility to alcohol and to the effects of the sun, may, if this person drinks alcohol or exposes himself to the rays of the sun, be indirectly responsible for lunacy.

"In insanity following an injury to the head there may be various supposed causative lesions: A fracture of the skull, with or without depression; the development of an exostosis; sclerosis or softening of the cortex; edema of the membranes or of the brain itself; cerebral hyperemia or congestion; thickening of the membranes; adhesion of the membranes to the skull, to each other, or to the brain; new-growth; inflammation of the membranes; or minute, slowly developing, wide-spread nutritive changes. The injury may be assumed to be the cause of the insanity if the insane condition becomes manifest almost at once or soon after the accident; but if the symptoms do not appear until long after the accident, the traumatism may be considered to be the directly exciting cause in some cases, and not in others. It may be blamed if, between the time of the accident and the appearance of the insanity, there has been a marked change in the patient's disposition, temperament, or character; if he has developed headache, insomnia, irritability, passionate outbreaks of temper, moodiness, or lapses of memory; if he has plunged into immorality or excesses in alcohol; if he has displayed a tendency to neglect business or family obligations; and if he has shown increased susceptibility to alcohol and to the sun. Sometimes epilepsy may develop during this period. (Richardson, 'American Journal of Insanity,' July, 1903. The author's 'Address on Surgery,' delivered before the meeting of the Medical Society of the State of Pennsylvania, May 18, 1897.) If there were none of these intermediate changes in the normal mode of thinking and way of acting, one cannot count the traumatism as causative. Many persons that have received severe head injuries have shown these changes, but have never gone insane. I have been studying this point for a number of years, and have

decided that quite a few patients that have been trephined for fracture or for meningeal hemorrhage have subsequently shown pronounced and permanent changes in character and disposition. Of the number that show such changes, many never go insane, but some do. Such an insanity is distinctly traumatic in origin." (The author in the "Journal of Nervous and Mental Diseases," June, 1904.) The prognosis is very unfavorable; some recover after operation, many do not. Some recover without operation. Sometimes operation cures by removing a lesion; sometimes by shock, etc. Some cures following operation did not result from the operation.

On what cases should we operate?

We should operate on cases "in which insanity has soon followed a head injury; if the site of the trauma is indicated by a scar, a depression of bone, local tenderness, fixed headache, or some localizing symptom,—motor or sensory,—operation should positively be undertaken. In a case in which the insanity has developed later, in which the intermediate period between the injury and the development of the insanity has shown the change from the normal mode of thinking and way of acting previously alluded to, and in which the site of trauma is indicated by any of the evidences mentioned above—operation should positively be performed. One should not operate upon a case simply because there is a dubious record of an antecedent fall or blow, which merely suggests the possibility of a traumatic origin for the insanity. In any case in which there are positive signs of increased pressure it may be considered proper to trephine as a palliative measure." (The author in the "Journal of Nervous and Mental Diseases," June, 1904.)

Abdominal, Gynecological, and Genito-urinary Operations.—If an insane person has a disease which is dangerous to life or which is productive of pain, discomfort, or ill health, he or she is entitled to be cured, if possible, by a surgical operation. The removal of pain and other depressing influences may result in great improvement in the general health and in notable mental improvement. The operation may thus indirectly exercise a beneficial influence on the insanity, but the influence is not direct and it is never justifiable to do such an operation as oöphorectomy upon an insane woman unless the condition of the ovaries would call for it in one not insane.

Operations on the Skull and Brain.—Trephining (for a fracture of the skull).—Shave the scalp, scrub it with ethereal soap and sterile water, wash it with sterile water and then with alcohol or ether, scrub with a brush wet with corrosive sublimate solution (1 : 1000), and wrap the scalp in wet corrosive sublimate gauze (1 : 2000). The instruments required are a scalpel, a dissector, hemostatic, dissecting, and mouse-toothed forceps, trephines of several sizes (Figs. 410 and 411), a periosteum elevator, Hey's saw, rongeur forceps, a bone-elevator, scissors, straight and curved on the flat, a dural separator, a tenaculum, small curved brain needles and large curved needles for the scalp; a needle-holder; catgut, fine silk, silkworm-gut, and Horsley's wax. Provide a sand-pillow. The patient should be anesthetized unless he is unconscious, and should be placed upon the back with the shoulders a little raised. A sand-pillow is placed under the neck, and his head is turned away from the side to be operated upon. The position of the surgeon is such that the patient's head is a little to his left. A large semilunar incision is made with the base down, which incision goes through the periosteum, and the flap

is lifted. The bleeding vessels of the flap are caught with forceps. The fracture is sought for and found. The pin of the trephine is projected beyond the crown and is set upon sound bone, the crown overhanging the line or edge of the fracture. The surgeon tries to avoid the region of a sinus or large artery. A gutter is cut in the bone, the pin of the instrument is withdrawn, and the trephining is completed. In going through the diploë bleeding is copious. The inner table feels very dense. Stop from time to time, clean out the gutter in the bone with the dissector, and try the bone with an elevator to see if it is loose. When the fragment is loose enough, pry it out. If the surgeon desires to replace the button, hand it to an assistant, who places it at once in a bowl of warm normal salt solution, kept warm by standing in a basin of water at 105° F., or who puts it in warm carbolized towels. The edges of the opening should be rounded with a rongeur, and the bone, if depressed, must be elevated. Sometimes it may be necessary to remove splinters and fragments of bone. After removing the fragments the edges of the opening should be smoothed by the use of the rongeur forceps. The dura should be examined to see if injury exists, and hemorrhage must be stopped. Bleeding from the dura is arrested by passing a ligature of silk or catgut threaded in a small curved needle under the vessel on each side of the wound, and tying the ligatures (*suture ligatures*). Bleeding from the pia is arrested by direct ligation, by suture ligature, or by gauze packing. Bleeding from the diploë is arrested by the use of Horsley's wax. The wound is cleansed, the edges of the dura are sutured with catgut or fine silk; in some cases the button of bone is reintroduced, in other cases some chips are cut from the bone and scattered upon the dura, but in most cases no attempt is made to fill up the gap in the bone. The scalp is sutured with silkworm-gut, and horse-hair or gauze drainage is employed for a day or two. Sterilized gauze dressings are put on, a rubber-dam is laid over them, and a gauze bandage wet with bichlorid of mercury is applied.

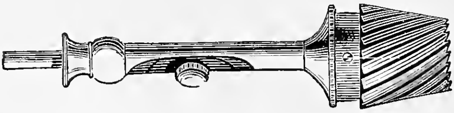


Fig. 410.—Galt's conical trephine.

Fig. 411.—Crown trephine.

Instead of the trephine some surgeons use the chisel or gouge and hammer to remove a portion of the bone. Other operators, believing that this procedure may cause concussion, employ the surgical engine.

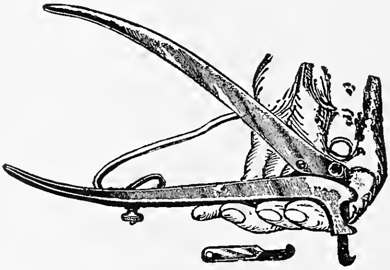


Fig. 412.—DeVilbiss bone-cutting forceps.

Osteoplastic Resection of the Skull.—Wolff suggested this operation, and in 1889 Wagner performed it. It is employed for the removal of tumors and the Gasserian ganglion for focal epilepsy, and for exploration. It is the

operation of choice when a large opening is needed, as when the operation is first of all for diagnosis. A horseshoe-shaped incision is made through the scalp and periosteum; a groove corresponding to this incision is cut in the bone by special gouges or chisels. Some surgeons prefer a saw attached to a surgical engine; some make trephine openings and then cut from within outward by the Gigli wire saw (Obalinski). Cushing, of Baltimore, does what he calls the combined method. I prefer this to any other plan. He makes two small openings through the skull and cuts the sides of his bone-flap by means of the De Vilbiss forceps (Fig. 412). The upper margin is cut on a bevel with the Gigli saw. Because of this bevel when the flap is restored to place, the upper edge of the flap rests on a shelf of bone and does not press on the brain.

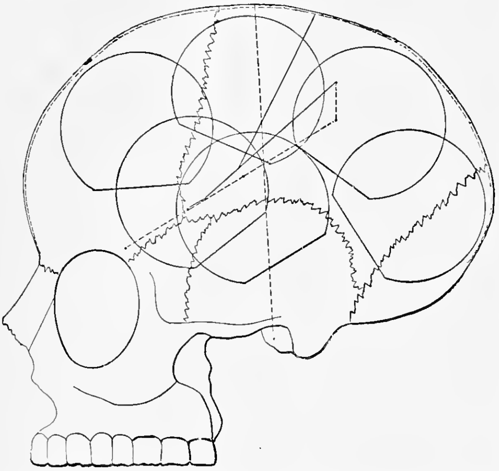


Fig. 413.—Cranial areas for osteoplastic operations with the Stellwagen trephine, these areas corresponding to the regions of the left hemicerebrum, with definite syndromes (Mills).

By whatever method preferred, three sides of the bone-flap are cut through, but the bone is left attached to the scalp. The bone is then broken outward,

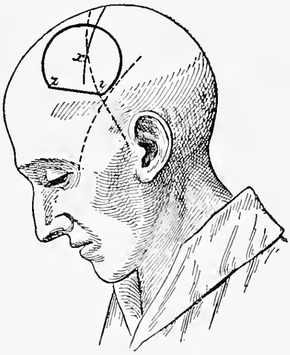


Fig. 414.—The motor region outlined on the skull previous to osteoplastic operation with the Stellwagen trephine: x, Point for the insertion of the pin of the Stellwagen trephine; y z, base line (Mills).

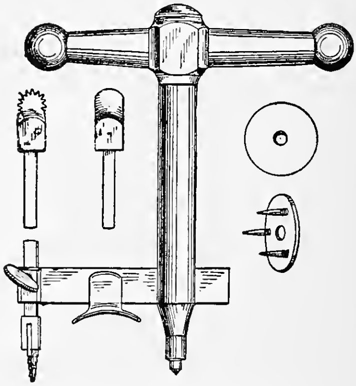


Fig. 415.—Stellwagen's trephine.

the fracture taking place at the base of the bone-flap, the dura is opened a little distance from the edge (sufficient space being retained for sutures), and the exploration is made and the operation is performed. When we are ready to

suture the dura, we note if the brain bulges greatly. If it does, manipulation will surely injure it and we should cause the brain to recede before suturing by placing the patient nearly erect or by performing lumbar puncture. After suturing the dura the bone which is still adherent to the pericranium is restored to its proper place, and the scalp is sutured.

Besides restoring a flap of bone into position, or replacing a button of bone, or strewing the dura with bone-fragments, other methods of closing the opening have been practised—for instance, heteroplasty with a decalcified bone-plate and heteroplasty with a celluloid plate or other foreign material.*

Osteoplastic Resection of the Skull by the Use of Stellwagen Trephine.—The concussion inflicted by the mallet I believe adds to shock, may increase or cause hemorrhage, may extend a line of fracture or produce fracture, and may diffuse a purulent collection. For these reasons I prefer a different plan. The surgical engine gives satisfaction to some, but it is difficult to render it sterile, and it runs at such a high rate of speed that regulation is troublesome and the instrument is dangerous except in the most careful hands. The trephine shown in the cut (Fig. 415) has proved satisfactory. It has since been modified by substituting screws for spikes in the pivot plate. Dr. Park suggested putting a handle to the spiked plate to keep it from slipping. The area of bone to be removed is carefully determined, as suggested by Mills (see Figs. 413 and 414), the plate is screwed into the skull, the scalp is cut with the knife-blade, the base of the flap being made narrow; the saw is substituted for the knife in the instrument. The bone is cut by short, quick cuts, making no attempt to swing the saw through the entire length of the incision at each turn of the wrist. When the inner plate is nearly cut through, the division is completed by a small osteotome. The operation can be completed on an ordinarily thick skull in from eight to eighteen minutes. (See article by author in "Annals of Surgery," July, 1903.) I still use this method, but not so frequently as formerly, preferring Cushing's combined plan to any other.

Trephining the Frontal Sinus.—This operation may be employed for inflammation of the lining membrane of the sinus or for empyema. Make a vertical incision in the middle of the forehead, starting one and one-half inches above the nasion and terminating at the root of the nose. The button of bone is removed and the opening is enlarged if necessary. The mucous membrane is incised, the opening into the nose is found and is dilated, and a drainage-tube is passed into the nose from the sinus, the upper end being left in the sinus. In some severe cases Jacobson advises us to curet the sinus, to disinfect it by the use of silver nitrate or chlorid of zinc, and to insufflate an "aseptic powder." In some cases resect the mucous membrane. I prefer an osteoplastic resection to trephining the frontal sinus.

Trephining the Mastoid (operation for mastoid suppuration, page 739).

Technique of Brain-operations (after Horsley and Keen).—Instruments as for fractured skull. In focal epilepsy a faradic battery is required. Always shave the scalp, and always antisepticize it. In localizations, mark out the fissure upon the scalp with an anilin pencil, with iodin, or with silver nitrate. Have the patient semirecumbent. Mark three points upon the bone with the center-pin of the trephine before incising the scalp (both ends

* See Bretano, in Deutsche med. Woch., May 17, 1894.

of the Rolandic fissure and the point at which the trephine is to be applied). Make a semilunar flap three inches in diameter, with the base below. Control bleeding in the flap by forceps pressure. The one and a half inch trephine should be employed, but if a smaller trephine is used, the opening must be enlarged with a rongeur. Before enlarging the opening, separate the dura from the bone by a dural separator. As a rule, open the dura and examine the brain. The dura is lifted by mouse-toothed forceps and is opened with scissors along a line a quarter of an inch from the bone-edge, a broad pedicle of dura being left uncut. Hemorrhage is arrested by pressure and hot water or by passing a thread of silk or catgut around any bleeding vessel by means of a curved needle. In some cases packing must be retained or forceps must be kept on. In packing, endeavor to use but one piece of gauze, so as to avoid leaving in a forgotten piece. Upon opening the dura cerebrospinal fluid flows out, the stream being increased with each expiration. Absence of pulsation of the brain points to abscess or tumor, and a livid color indicates subcortical growth. An old laceration is brownish. If the brain bulges through the opening, it means increased pressure (tumor, abscess, effusion into the ventricles, etc.). After opening the dura employ no antiseptics, especially when the surgeon intends using electricity to locate a center. Irrigate only with warm salt solution. In operating for tumor the dura is opened and in some cases the brain is incised. The tumor is turned out by the finger, or, if this is impossible, by the dry dissector, the scissors, the dull knife, or the sharp spoon. If the entire tumor cannot be removed, it is sometimes proper to take away as much as possible. The removal of a portion often retards the growth of the remainder, and the trephining, by lessening cerebral pressure, relieves the symptoms and prolongs life. After removing a tumor arrest distinct points of bleeding with the ligature alone or the ligature passed around the vessel by means of a needle. Pack the tumor cavity with gauze and bring the end of the strand out of the wound. Stitch the dura with silk and suture the scalp with silkworm-gut. In electrifying the brain faradism is employed of a strength about sufficient to move the thenar muscles when applied to them. The current is applied to the motor area by the double electrode. A careful observer watches the muscular movements. If, for instance, the surgeon wishes to remove the thumb center, he moves the electrode from point to point until he obtains thumb movements. The region is sliced away bit by bit until the center which is responsible for the convulsive movements is removed. It will be found impossible to remove only the thumb center. Adjacent centers are sure to be more or less damaged, and a certain amount of paralysis follows the operation. If we wish to *tap the ventricles*, Keen directs the trephine opening to be one and one-fourth inches behind the external auditory meatus and the same distance above the base-line of Reid (Fig. 416, *a*). A grooved director or metal tube is passed into the brain in the direction of a point "two and one-half to three inches above the opposite meatus." The normal ventricle will be entered at a depth of two to two and one-fourth inches, but the dilated ventricle will be entered sooner (Keen). The moment of entry is marked by lessened resistance and a flow of cerebrospinal fluid. Drainage can be maintained by introducing a rubber tube. This operation has been employed in hydrocephalus. After an aseptic cerebral operation, as a rule, do not drain unless hemorrhage has been con-

siderable. In many cases replace the bone, but not when the bone is diseased, is infected, or is very compact, or if it is desired to alter pressure. The dura is sutured by a continuous suture of silk or catgut; the scalp is sutured by interrupted silkworm-gut sutures.

Operation for Mastoid Suppuration.—The instruments required in this operation are a scalpel, a gouge, a chisel, a mallet, curets, a probe, a dissector, dissecting and hemostatic forceps, and needles. Provide a sandbag to place under the neck. An incision is made one-quarter of an inch posterior to the auricle and down to the bone, and in the direction of the

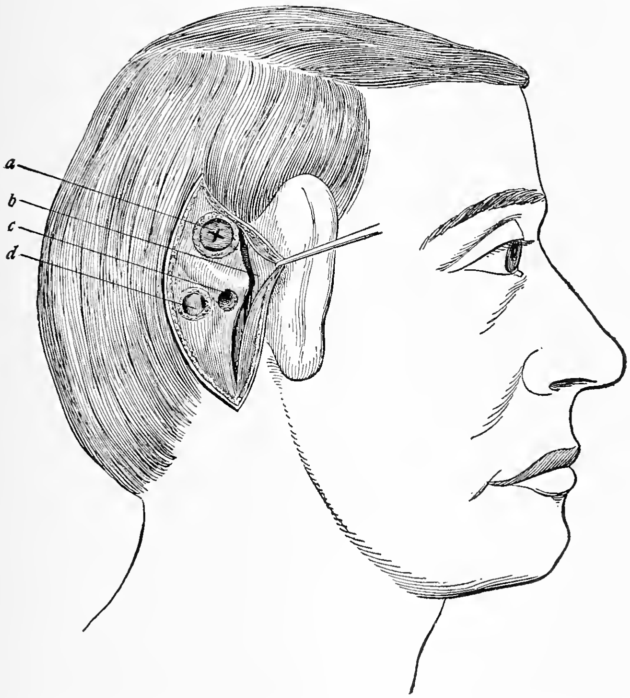


Fig. 416.—Opening the mastoid antrum and the lateral sinus; exposure of the temporo-sphenoidal lobe and puncture of the descending horn of the lateral ventricle: *a*, Temporo-sphenoidal lobe (descending cornu of lateral ventricle is 1 cm. deeper); *b*, inner surface of periosteum; *c*, mastoid antrum; *d*, lateral sinus (Kocher).

long axis of the mastoid. The bone is bared and examined, especially at a point in the line of the incision, which is on a level with the roof of the meatus (Fig. 416, *c*). The bone will usually be found softened. Gouge it away and thus open the mastoid antrum. The bone-opening is within the limits of *Macewen's suprameatal triangle*, a space bonnded by the posterior root of the zygoma, the posterior bony wall of the meatus, and an imaginary line joining the two. If the mastoid is opened in this triangle, the antrum is entered directly and there is no chance of wounding the lateral sinus. If, in the adult, pus is not found on opening the mastoid antrum, gouge downward and backward, but with great care, so as to avoid the lateral sinus.

If there be any possibility of the existence of pus in the groove of the sinus, the sinus should be unhesitatingly exposed. After evacuating the pus from the mastoid gouge away bony septa, enlarge the opening between the mastoid and the middle ear with the gouge and remove the posterior bony wall of the meatus (avoid the facial nerve on the floor of the meatus), turn the head toward the side operated upon, and irrigate the mastoid with salt solution, dust with iodoform, pack with iodoform gauze for a few days, and then introduce a silver drainage-tube. Treat the causative ear disease. Sheild and Macewen operate on inveterate cases of mastoid disease as follows: A thick flap is raised behind the auricle, the flap including the orifice of any sinus and being "left attached by its stalk." The auricle is "detached forward and the soft parts over the mastoid are turned backward by horizontal incision." The "lining membrane of the canal is separated from the bone." The mastoid is opened and dead bone and caseous matter are removed, overhanging edges are chiseled down, and the posterior bony wall of the external auditory meatus is gouged away. The skin-flap is pushed into the cavity and is held in place with pads of gauze. The margins of the flap may be sutured, but this is not necessary. Macewen calls this procedure "papering" the cavity with skin.*

If mastoid suppuration has established *abscess in the temporo-sphenoidal* lobe, trephine, one and a quarter inches behind and one and a quarter inches above the middle of the external meatus (Barker's point), and search for pus as directed on page 718. If *abscess of the cerebellum* exists, trephine below the line of the lateral sinus. "The position of the lateral sinus is indicated by a line running horizontally outward from the occipital protuberance to within about an inch of the external auditory meatus, and thence downward to the mastoid process" (Owen's "Manual of Anatomy"). If *infective sinus-thrombosis* exists, break into the lateral sinus (Fig. 416, *d*) from the mastoid opening and proceed as directed on page 721.

Linear Craniotomy.—Instruments as for any brain operation, plus, however, several kinds of rongeur forceps. Make a large flap. Trephine the skull a finger's breadth from the sagittal suture, and the same distance back of the coronal suture. Rongeur the bone away in a line parallel with the sagittal suture and a safe distance from the longitudinal sinus, up to a point in front of the lambdoidal suture. Remove the pericranium which covered the bone excised. Insert the dural separator, or pass it along the margins. In some cases an additional portion of the bone is removed over the fissure of Rolando. Various suggestions have been made as to the direction and situation of bone-sections. Bleeding is arrested and the flap is closed without drainage.

Removal of Gasserian Ganglion.—(See page 682.)

Operation for Infective Sinus-thrombosis.—(See page 721.)

XXIV. SURGERY OF THE SPINE.

Congenital Deformities.—*Myelocele or Rachischisis.*—This condition is due to deficiency in the formation of the vertebral arches, the cord being rudimentary, the medullary plates having failed to coalesce, the central

*Lancet, Feb. 8, 1896.

canal not having formed, and the endothelium which should line it being exposed. If the entire cord is involved, the condition is called *amyelia* or *total rachischisis*. If a part of the cord is involved, the condition is called *partial rachischisis*. In partial rachischisis a portion of skin is absent in the midline. At this area is a circular, dark-red focus surrounded by a very thin and glistening membrane which becomes continuous with the skin. A dimple at the upper part and a dimple at the lower part of the dark area indicates the situation of the central canal above and below. Victims of rachischisis are usually stillborn or at most live but a few days.

Spina Bifida.—This is a deformity similar to the one just discussed, but in it the cord is much more developed. The first accurate description of it was given by Tulpius in 1685. It is a congenital sac of fluid due to vertebral deficiency, permitting protrusion of the contents of the spinal canal in the median line. In this condition the cutaneous epiblast is adherent to the spinal exiblast, because structures from the mesoblast have failed to grow between. The laminæ or spines of one vertebra or of several vertebræ or of many vertebræ may be deficient, most frequently in the lumbosacral region. In very rare cases there is division of the vertebral bodies and the projection is foward and to the side. A case in which there are ununited laminæ but no protrusion is called *spina bifida occulta*. Sometimes there are two protrusions in one person. In spina bifida the dura does not cover the sac because it is cleft as well as the laminæ. There are three distinct varieties of spina bifida: 1. *Meningocele*. In this condition the dura is cleft (Hildebrand), there is a protrusion of the arachnoid, fluid gathers in the arachnoid meshes and "distends this so as to form one continuous cavity which is traversed by nerve-roots" (Henle, in "A System of Practical Surgery" by von Bergmann, Bruns, and von Mikulicz. Translated and edited by Wm. T. Bull and Carlton P. Flint). The cord is not in the sac. 2. *Meningomyelocele* (the commonest form) is a protrusion of arachnoid, the sac containing cerebrospinal fluid, nerves, and cord-substance. The cord may spread upon the sac-wall or it may pass through the sac and reënter the canal. A cutaneous dimple or furrow indicates that the cord is attached and hence is within the sac. 3. *Syringomyelocele* is great distention of the central canal, the sac-wall being formed of the thinned cord and the spinal membranes. A spina bifida varies in size from that of a walnut to that of an infant's head; it grows rapidly during the early weeks of life; it is usually sessile, but may present, where it joins the body, a definite constriction, or even a pedicle; the base of the sac is covered with healthy skin, and the fundus is covered only by thin epidermis or by the spinal membranes themselves. Pressure upon the tumor may diminish its size and increase the tension of the anterior fontanelle, and possibly cause convulsions or stupor. The cyst is translucent, and the margins of the bony aperture are distinct. Crying, coughing, or pressure upon the anterior fontanelle makes the tumor more tense. Spina bifida is apt to be associated with club-foot, with hydrocephalus, and with rectal or vesical paralysis. Spina bifida usually causes death. A few meningoceles and a very few meningomyeloceles undergo spontaneous cure by growth of the vertebral arches constricting the neck of the sac. The sac may remain distended with fluid or may shrink. Syringomyelocele is invariably fatal. The cause of death may be rupture of the

sac or marasmus. The x-rays show the bony gap. *Spina bifida occulta* is a cleft in the vertebral column without any protrusion of the cord or the membranes. In this condition there is usually a profuse growth of hair in the skin over the bony gap and the hairy condition may be much more wide-spread. In some cases the hair is present at birth; in others it appears at puberty. Trophic changes and deformities may exist in the lower extremities.

Treatment.—Very small protrusions which grow slowly and are covered with sound skin may be treated by the use of a compress and bandage, by an elastic bandage, or by applications of contractile collodion. It was formerly regarded as proper to tap and drain the sac. Injection was used by many. The skin being cleansed, the child was placed on its side and a little chloroform was given. A fine trocar was plunged obliquely in at the side of the sac through sound skin, little or no fluid being drawn off, and ʒj of Morton's fluid injected (iodin, gr. x; iodid of potassium, gr. xxx; glycerin, ℥j). The trocar was withdrawn and the puncture was sealed with a bit of gauze and iodoform collodion. The child was put to bed. If injection proved successful, the sac was found to shrink; if the injection failed, it was the custom to repeat it at intervals of from seven to ten days (Jacobson, White). Surgeons now prefer excision of the sac. Bayer treats it as he would a hernia. Robson in some cases excises the entire sac. Operations upon children under the age of five have an enormous mortality. Operations are comparatively safe when the child reaches the age of five. We should not operate if there is hydrocephalus or paralysis, or if the mass is very large and growing rapidly (James E. Moore, in "Surgery, Gynecology, and Obstetrics," August, 1905).

Sacrococcygeal Tumors.—Dermoids external to the sacrum are occasionally seen in this region. Dermoids also arise between the rectum and sacrum. In the lower sacral or coccygeal region the cutaneous structures sometimes fail of complete coalescence and a *post-anal dimple* or *sinus* is the result. Such a sinus is lined with skin and its wall contains numerous glands and often hairs. It may inflame or suppurate. If it blocks up at the outlet, a form of dermoid develops. Teratomata, lipomata, and hydatid cysts may develop in the sacrococcygeal region.

Treatment.—Dermoids require extirpation. If a post-anal dimple causes no trouble, it is let alone; otherwise it is dissected out. It may or may not be possible to remove teratomata. Lipomata and hydatids are extirpated.

Anosacral Cysts.—These cysts develop between the sacrum and rectum and originate from remnants of the post-anal gut and neurenteric canal. Such cysts may be multilocular or unilocular. They can be detected by a finger in the rectum.

Treatment.—Some of these growths are removed after osteoplastic resection of a portion of the sacrum; some are removed by incising the rectal wall.

Tumors of the Spinal Cord.—Among congenital tumors are lipomata and cysts (dermoid, congenital, sacral, and fetal). Tuberculoma, gumma, psammoma, and fibroma may arise from the cord or its membranes. Glioma is the most usual growth. Primary sarcoma is rare. Angioma may occur. Primary carcinoma does not occur in this region. A tumor rarely produces obvious symptoms until it is as large as a hazel-nut.

Symptoms.—Pain, stiffness of the back, areas of anesthesia, and progressively advancing motor paralysis are symptoms of spinal tumors. A tumor

may produce the symptoms of compression-myelitis, locomotor ataxia, or myelitis. In glioma there are apt to be loss of ability to recognize variations of temperature (or even to distinguish between heat and cold), loss of the sense of pain, and paresis and atrophy of muscles. Contractures or paraplegia may arise from tumor. The location of the growth can be inferred by a study of the territory of paralysis and the zone of sensory disturbance. The tumor is always situated somewhat above the upper limit of anesthesia. In many cases the diagnosis is impossible. Gradually increasing painful paraplegia with pain in the back and with sensory paralysis after a time appearing and ascending from the feet toward the trunk, points to tumor as a cause. The reflexes are at first increased, but are finally lost from below upward. Spasms may develop, and lateral spinal curvature may arise. If curvature arises, the concavity of the curve will be on the side of the tumor. Growths outside the membranes produce particularly pain and spasm; growths within the membranes produce especially motor paralysis and anesthesia.

Treatment.—If syphilis is suspected, give the patient a course of heroic doses of iodid of potassium, and administer mercury hypodermatically or by inunction. In a focal lesion not due to dissemination of a known malignant growth perform the operation of laminectomy to permit of exploration and possibly of removal. The laminæ of at least three vertebræ should be removed and the tumor is looked for distinctly above the upper level of the zone of anesthesia. It is not necessary for the patient to wear a spinal support after the performance of laminectomy. McCosh truly says that operation for spinal-cord tumor is decidedly more hopeful than for brain-tumor because localization is much more accurate and removal can be effected with less permanent damage. Lloyd collected 51 operations: 10 per cent. died and 31 per cent. were actually cured or improved. Joseph Collins ("Med. Record," Dec. 6, 1902) collected 70 cases of spinal tumor, 30 of which were operated upon. In 12 the operation was a success, that is, the pain disappeared and motor power returned; in 8 the operation was partly successful, that is, the pain disappeared and the motor power improved; in 10 the operation failed and death occurred within a few weeks. If the tumor is found to be irremovable, McCosh suggests division of several nerve-roots to relieve the pain.

Acute osteomyelitis of the vertebræ is a rare disease; it may be associated with osteomyelitis of other bones, may be secondary to some distant suppurative focus, but may occur alone. Infections of the viscera not unusually accompany it. In many cases there is a history of trauma. Any part of a vertebra may suffer from it. This condition may follow cold, overexertion, or traumatism, and is more common in the first two decades of life than in elderly people. The process may be superficial, or it may involve the bone deeply and widely. Suppuration always occurs; sequestra generally form; and phlebitis is a dangerous complication. Any region of the spine may be attacked, but the lumbar region is particularly liable to invasion, next the dorsal, next the cervical. The sacral region is least often affected. The situation of the abscess varies with the situation of the disease. If the vertebral bodies are diseased, the pus passes forward (retropharyngeal, mediastinal, psoas, or pelvic abscess). If the vertebral arches suffer, the pus passes backward (lumbar or dorsal abscess). The membranes of the cord, the cord itself, the nerves, and the vertebral articulations are fre-

quently involved in the process. Staphylococci, streptococci, or other pyogenic bacteria may be cultivated from the pus.

Symptoms.—The general symptoms are those of osteomyelitis. The local symptoms depend on the seat of disease. If the posterior portion of the column is diseased, there is a hard swelling, which, in the neck, is in the middle line; in the dorsal and lumbar regions, in the middle or to the side; and in the sacral region, invariably to one side.

Rigidity of the spine always exists. If the vertebral bodies are affected, rigidity is noted, the spine is tender, and special symptoms appear, their nature dependent on the region affected (retropharyngeal abscess, etc.). Occasionally symptoms of meningomyelitis are noted. The constitutional symptoms of sepsis are marked. The condition is sudden in onset, and purulent collections diffuse widely and rapidly. These points enable the surgeon to make a diagnosis between osteomyelitis and Pott's disease. In osteomyelitis angular deformity very rarely arises, because the patient is obliged to be recumbent and because hyperostosis is taking place. The mortality, according to Hahn, is 60 per cent. Death may be due to pachymeningitis, pneumonia, empyema, retropharyngeal abscess, invasion of the cord, or amyloid disease (H. S. Warren, "Boston Med. and Surg. Jour.," May 7, 1903).

Treatment.—The patient is kept recumbent. His constitutional treatment is such as will combat sepsis (food, stimulants, etc.). A puriform area must be incised and disinfected. If bone denuded of periosteum is found, it is touched with a solution of chlorid of zinc or with the actual cautery. If a sequestrum exists, it is removed. A drainage-tube is inserted and dressings are applied (Müller, Makins, Abbot, and Chipault).

Typhoid Spine.—It was pointed out by Gibney that typhoid fever may leave as a legacy a painful, stiff, and weak back. The muscles of the back are found to be rigid and there is tenderness of one or more vertebræ. The pain may only be appreciated on motion, but in some cases there is aching even when the patient is at rest. The pain may be localized, may run into one or both thighs, or may be felt in the abdomen. The symptoms arise at an uncertain period after the fever, develop rapidly, and are occasionally associated with transient episodes of fever. Kyphosis or lateral curvature may develop. (See L. W. Ely, "Medical Record," Dec. 20, 1902.) Usually the patient is hysterical. The condition is due to osteitis and periostitis, or chronic osteomyelitis. The prognosis is excellent.

Treatment.—The use of a plaster or leather jacket; counterirritation by the hot iron; and later massage and electricity.

Cervical Rib.—This condition was first described by Hunauld in 1743. The anterior limb of the transverse process of the seventh cervical vertebra, which has an independent center of ossification, may develop into a separate bone of large size, known as a cervical rib. Such a rib may form on one side or on both. Such a rib may scarcely reach beyond the transverse process, it may project well beyond the transverse process and have a free end, or it may constitute a complete rib which fuses anteriorly with the sternum, the cartilage of the first rib, or with a cervical rib of the opposite side.

Most instances described were found in the dead body, although Tillmanns collected 26 cases among the living (Carl Beck, in "Jour. Am. Med. Assoc.,"

June 17, 1905). Of late x-ray findings indicate that the condition is much more common than was formerly supposed. I have seen 3 cases. It may never produce any uneasiness and hence may escape detection and seldom does produce trouble in youth. It may lead to damage of the subclavian artery (Keen's case developed aneurysm), or gangrene of the hand may result from bending of the vessel, or neuritis of the brachial plexus may arise from pressure. When sufficiently large to produce venous or vascular trouble, a cervical rib can be felt and the pulsating artery over it is very distinct and higher than natural in the neck. The x-rays confirm the diagnosis. The treatment, when the rib is causing trouble, is excision of the rib with its periosteum (page 785). (See Kammerer, in "Annals of Surg.," Nov., 1901, on "The Diagnostic Difficulties.")

Spinal Curvatures.—There are four chief forms of spinal curvature: (1) Lateral curvature (the scoliosis of the older surgeons); (2) posterior curvature (the excurvation, gibbosity, or kyphosis of the older surgeons); (3) anterior curvature (the lordosis of the older surgeons); and (4) angular curvature (from spinal caries). The normal spine has four curves: the *cervical* curve, the convexity of which is forward; the *dorsal* curve, the convexity of which is backward; the *lumbar* curve, which is convex anteriorly; and the *pelvic* curve, which is concave anteriorly. The dorsal and the pelvic curves, which are primary, are due to the formation of the cavities of the chest and pelvis, and depend upon the shape of the bones (Treves). The cervical and lumbar curves, which are compensatory, depend upon the shape of the intervertebral discs, and only appear after birth when the erect position is assumed.

Fig. 417.—Lateral dorsal curvature to the right, and compensatory lumbar curve to the left.

Lateral curvature (*scoliosis*) is a lateral deviation of the spinal column, often accompanied by rotation of the vertebræ and associated with increase or with diminution of the normal curves. Lateral curvature is predisposed to by weak muscles and ligaments, by the habitual assumption of strained and unnatural attitudes, by unequal length of the legs, and by paralysis of one leg. This distortion, which is commonest in girls, is apt to arise at the age of puberty (it is usually corrected in boys by outdoor exercise). The bones are soft and the muscles are weak, and this condition is often inherited. Rickets is very commonly associated with lateral curvature. Any condition of ill-health weakens the muscles; hence lateral curvature may arise after an acute sickness or in a person who outgrows his strength. An empyema with adhesions, by pulling on the chest-wall, may produce a curvature the concavity of which is toward the diseased side.

The weak muscles cease to sustain the spinal column, and the ligaments stretch, relax, or lengthen. The commonest curve is toward the right in the dorsal region (because most people use the right hand more than the left). As soon as a dorsal curve to the right arises, a compensatory lumbar curve (Fig. 417) takes place to the left, thus enabling the patient still to sit or to stand erect. In almost all cases the vertebræ soon rotate, the bodies turning to the convexity and the spines turning to the concavity of the curve;

hence the transverse processes toward the convexity project. The ribs follow the spinal rotation; the shoulder is elevated on the side of the convexity, and the hip on the opposite side is apparently, but not in reality, raised. As a matter of fact, the hip becomes prominent rather than raised. The intervertebral discs are apt to flatten out on the concavity of the curve. In very rare instances lateral curvature results from caries of a half of one or of several vertebræ. In a spinal tumor lateral curvature may occur, the concavity of the bend being on the side of the growth.

Symptoms.—An ordinary case of spinal curvature from weak muscles arises gradually. Stooping is noticed, and after a time pain is complained of in the dorsal and lumbar regions, and weakness in the back is detected by the sufferer. The pain is made severe by sitting long in one attitude. Anemia is manifest, and walking is awkward and ungraceful. When the shoes and clothing are removed, and the child stands with its back toward the surgeon and with the feet symmetrically together, the lower angle of the right scapula (in a dorsal curvature to the right) is unduly prominent and is elevated above the left; the normal prominence of the right iliac crest is lost; the left iliac crest is unduly distinct; on marking the spinous processes with an anilin pencil the curve becomes manifest; tenderness is developed on pressing the spines only if there is marked neurasthenia; the normal dorsal anteroposterior curve is exaggerated; the abdomen is protuberant; the chest is flattened; the neck juts forward; and the breast on the same side as the concavity of the curve is more prominent and on a lower level than the other breast. Always observe if the anterior iliac spines are on a level or not, and always measure the length of the legs. The patient, with the knees extended, bends forward with the arms hanging loosely; the erector spinæ muscle between the iliac crest and the last rib is seen to be more prominent on the convexity of the lumbar curve than on its concavity (Bernard Roth), and the angles of the ribs on the side of the convexity of the dorsal curve are on a higher level than are those on its concavity. Have the child assume what it supposes to be an erect attitude, and let the surgeon correct this into the best possible position (Roth), and see how long the new position can voluntarily be maintained. A large percentage of these patients labor under pes planus. When there is no osseous deformity (that is, when the surgeon may, by manipulation and traction, correct the deformity), and when the spinal muscles are not paralyzed, the prognosis is good for complete cure. Roth states that cases without osseous deformity can practically be cured in one month, but the treatment must be continued for one year to prevent relapse.* In a case with moderate osseous deformity the patient can be improved vastly by three months' daily treatment (Roth). Even in severe cases of bony deformity the pain may be relieved and the deformity be modified.

Treatment.—If one leg is too short, let the patient wear a thick-soled shoe. No treatment for weak muscles has ever been devised so utterly irrational and absurd as the prevention of all movement; and neglect of all treatment for lateral curvature does less harm in the vast majority of cases than immobilizing the spinal muscles by braces and supports. The muscular nutrition in these cases is to be restored, as is muscular nutrition in any other region, by scientific gymnastics, electricity, the douche, salt baths, frictions, and massage. Bicy-

* Heath's "Dictionary of Practical Surgery."

cles with specially constructed seats are used with advantage in some cases. The mode of exercise to be used should be directed by some one skilled in orthopedics, and the instruction in the details must be thorough and persistent. Roth's advice is to so reëducate the muscular sense that a patient can again know whether she is or is not standing straight; to maintain an improved position in sitting and standing; to use such clothing as will not interfere with the assumption of a normal attitude; to enforce systematic training of the muscles of the spine and thorax; and to give attention to the general health. In some cases where, in spite of all attempts at correction, deformity increases, it may be necessary to immobilize in hope of obtaining ankylosis and preventing further deformity. In those rare lateral curvatures due to caries a supporting apparatus must, of course, be applied.

Anteroposterior curvature (not from spinal caries or from hip-joint disease) is an increase of the normal anteroposterior curves. Increase of the dorsal curve is *posterior curvature, kyphosis*, or *excurvation* (Fig. 418, A); increase of the lumbar curve is *anterior curvature, lordosis*, or *saddle-back* (Fig. 418, B). Both lordosis and kyphosis are apt to be present. Scoliosis has nearly always some anteroposterior curvature associated with it. Lordosis is apt to be compensatory, to prevent the center of gravity going too far forward. Lordosis is found in pregnant women and in very fat men. In an old man kyphosis arises from flattening out of the vertebral discs from pressure. Rheumatic gout may cause anteroposterior curvature. Anteroposterior curvature is often due to paralysis of the erector spinæ mass (from infantile paralysis). Pseudohypertrophic paralysis causes lordosis.

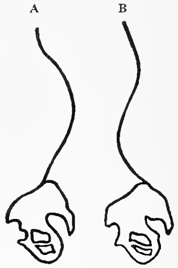


Fig. 418.— Kyphosis (A) and lordosis (B).

Symptoms and Treatment.—The symptoms of anteroposterior curvature are as follows: the thorax is flattened or pigeon-breasted; the shoulder-blades are widely separated and the scapular angles project; the abdomen is protuberant; the patient complains of backache and soon tires. A recent kyphosis disappears when the patient lies upon his stomach. The facts that the erector spinæ muscles are soft, and that pain is absent on concussion transmitted to the back, separate kyphosis from caries. Lordosis is unmistakable. When the spine is movable, employ the same plan of *treatment* as in lateral curvature, suiting the gymnastics to the deformity (Roth). In painful kyphosis with partial ankylosis endeavor to make the ankylosis complete in order to prevent pain, obtaining this result by applying a plaster jacket which laces up and letting the patient wear it for several years.

Angular curvature (*spinal caries; spondylitis; Pott's disease*) is usually due to tuberculous caries of the vertebral bodies, and occurs particularly in children who are predisposed to tuberculosis, but it may arise at any age. Any portion of the spinal column may be attacked. The dorsolumbar region is most prone to suffer. The chief *cause* is tuberculosis, but syphilis and secondary cancer of the vertebræ are occasional causes, and acute osteomyelitis is a very rare cause (page 744). Blows or strains may act as exciting causes. Angular curvature may develop after an exanthematous fever.

The cancellous tissue of the anterior portion of the vertebral body becomes

primarily carious, or the inflammation begins in an intervertebral disc. (The changes of tuberculous osteitis have previously been set forth—pages 213, 232, and 435.) The body of the vertebra and the vertebral disc are destroyed, and the process extends to adjacent vertebræ. The weight which rests upon the spinal column causes softened bone to crumble, compresses the diseased vertebræ and discs, and produces angular deformity (the anterior part of the column formed by the vertebral bodies is shortened, the posterior part is not, and hence the spines project). In some cases the disease is spontaneously arrested by organization of inflammatory products, and ankylosis (fibrous or bony) in deformity is nature's cure. In most cases, however, the disease spreads and caseous pus is formed, which, according to the point of formation and the route it takes, causes lumbar abscess, dorsal abscess, psoas abscess, or post-pharyngeal abscess (pages 151 and 152). In some cases the spinal cord is compressed, but in most cases it is not, and even when it is compressed, paraplegia is rare and is usually temporary. Compression of the cord may be caused by the displaced vertebræ or by inflammatory material or caseous matter between the bone and dura mater, but is most often due to pachymeningitis. Caries of the cervical region constitutes a more dangerous disease than caries of either the dorsal or the lumbar region (*dangerous* pressure occurs more easily). Death may be caused by exhaustion, sepsis, hemorrhage, amyloid disease, pneumonia, peritonitis, pleuritis, tuberculous dissemination, pressure upon the cord, or inflammation of the cord or its membranes.

Symptoms.—The sufferer from Pott's disease, if a child, grows tired easily, his disposition alters, he becomes moody and irritable, and complains of vague pains in many places, is disposed to lean, rest, or lie down, and walks with the back rigid, which produces a peculiar gait. A painful spot is found by pressing upon the spines. Faradism to the back causes pain. Spasm of the erector spinæ mass is detected (Hilton, Golding-Bird). It is not proper to seek to develop pain by jarring the back or by pressing the head downward. The posture of the child and the muscular rigidity prove the existence of inflammation, and to seek to develop pain by the methods referred to may do harm, and at best can only call attention to what is already known. Pain in the back, which is increased by motion, by pressure, and by vertebral jars, may be absent until late in the case. Distinct pain and tenderness in the back often mean abscess-formation. Neuralgic pains pass into distant parts (sciatica, intercostal neuralgia) and are often linked with muscular spasm. A chronic bilateral pain in the trunk or extremities is suggestive of Pott's disease. "Chronic bilateral belly-aches in children are almost diagnostic" (Jordan Lloyd). The pain of dorsal caries can be relieved by lifting the shoulders; the pain of cervical caries, by traction on the head. Cramp in the legs occurs in dorsal and in lumbar caries. The presence of the knuckle due to bending the spine at an acute angle is a very important sign of the disease. In many cases angular deformity appears late; in some cases it does not appear at all. An angular deformity is detected sooner in those regions where the normal curves are posterior than where the normal curves are anterior (Jordan Lloyd). The deformity appears early in the dorsal region, but late in the cervical and lumbar regions. In some rare cases lateral deformity occurs. Rigidity is an early sign of great importance. It is always present. Rigidity is manifest very early in cervical

caries, tolerably early in lumbar caries, late in dorsal caries. Lloyd gives the following practical rules to enable us to detect rigidity.* In the cervical region: seat the patient in a chair and tell him to nod the head affirmatively. Stiffness in nodding points to occipito-atloid disease. Tell him to look far to the right and then far to the left. Stiffness of these motions suggests atlo-axoid disease. Tell him to place his shoulders against the back of the chair and carry his eyes back along the ceiling. Stiffness in this movement indicates disease below the second cervical vertebra. It is practically useless to examine the dorsal region of an adult for rigidity, but such an examination can be made in a child. Place the patient prone on an adult's lap, mark the tip of each spinous process with an anilin pencil, then make the child stand up straight on the floor, and observe if any of the pencil marks fail to come nearer together. If it is seen that two or more marks do not approach each other, there is rigidity which prevents approximation. To test for rigidity in the lumbar

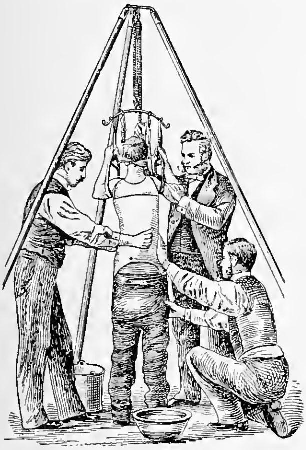


Fig. 419.—Plaster-of-Paris jacket (Sayre).

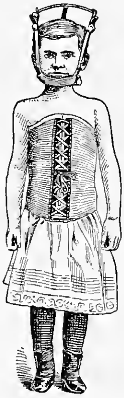


Fig. 420.—Plaster-of-Paris jacket and jury-mast applied (Sayre).

region lay the naked patient prone upon a couch. Grasp the patient's ankles and raise the pelvis from the couch. If the lumbar spine is flexible, the pelvis can be lifted without raising the chest from the bed, and the maneuver deepens the hollow of the loin. If the lumbar spine is stiff, the maneuver lifts the trunk and produces no alteration in the vertical outline of the lumbar spines. If a child with Pott's disease is asked to pick up something from the ground, because of rigidity or pain on movement he will not bend the back, but will bend the knees or get upon the knees. Paralysis may exist, and it is due to pachymeningitis more often than to pressure from bone. Cervical caries causes dyspnea and torticollis, the head requiring support with the hands. Dysphagia indicates abscess. In adults the first signs of Pott's disease to attract attention are headache, backache, neuralgia, girdle-pain, cramp, or even paralysis. In abscess due to caries of the dorsolumbar vertebræ the pus usually enters the psoas muscle and passes out of the pelvis below the junction of the middle and outer thirds of Poupart's ligament.

* Birmingham Med. Review, April, 1897.

It may point here or may pass to the inner aspect of the thigh and point a little below the spot where a femoral hernia is met with if it exists. In a psoas abscess a mass is always felt in the iliac fossa above Poupart's ligament; in a hernia no such mass exists (J. T. Rugh). In sacral caries there is no deformity and frequently no pain. The diagnosis becomes apparent when bilateral abscess is detected in the buttocks or groins (Jordan Lloyd). If an abscess due to spinal caries opens spontaneously, healing will not occur, but mixed infection takes place and death, as a rule, soon follows.

Treatment of Caries of the Spine.—When recent caries of the spine is active and affects a child; when it is accompanied by pain and fever; and when paralysis threatens, insist upon perfect rest. Place the child supine on a hard mattress, and, if possible, take it, while in a rolling bed, out of doors daily. Leeches, blisters, or the hot iron over the area of pain may do good. When the activity of the process abates, apply a fixation apparatus. In diseases at or near the vertebro-occipital articulation, as long as dyspnea persists, keep the patient supine with a small hard pillow under the nape of the neck (Hilton) and a sand-bag on each side of the head and neck. After several months mechanical support can be given by Furneaux Jordan's method. Jordan applies his support as follows: The patient lies on a flat, hard table, his arms are raised above his head, and traction is made upon the head by means of a pulley and a weight. Cotton pads are placed over the ears, the back of the neck, and the clavicles, and are held in place by a flannel bandage applied as a figure-of-eight on the head, neck, and chest. The flannel bandage is overlaid with plaster-of-Paris bandages.* In disease of the cervical region below the axis, or of the dorsal region above the seventh vertebra, use Sayre's jury-mast (Fig. 420), or some other form of head support. Instead of the jury-mast a steel upright may be used to hold the head rigid. Sayre's appliance relieves the spine from the weight of the head and acts admirably. In most cases of dorsal and lumbar caries a steel, leather, or plaster jacket as a fixation apparatus must be employed. The best of all fixation apparatus is Sayre's plaster-of-Paris jacket applied while the patient is suspended (Fig. 419), or better, while the column is in hyperextension. The Sayre apparatus applied in this manner is used for the treatment of caries of the lumbar region and the lower half of the dorsal region. When all subjective signs cease, substitute for Sayre's jacket a felt or sole-leather jacket which laces down the front. Caries of the upper half of the dorsal region is often treated by a Sayre's jury-mast (Fig. 420); but if the jury-mast fails, it may be necessary to place the patient horizontally in "an open cuirass, fitted to the back from occiput to sacrum, and combined with pulley extension to the head and pelvis." †

During the course of caries of the spine have the patient eat fat-forming and nutritious food, insist on a plentiful supply of fresh air, and administer tonics and antituberculous drugs. Sea-air is very beneficial. When all active disease ceases and only angular curvature remains, use an apparatus to combine extension with mechanical support, the plaster jacket being generally employed.

Spinal abscesses are treated as indicated on pages 153, 154, and 618.

* See "Children's Deformities," by Walter Pye.
† Jordan Lloyd, in Birmingham Med. Review, April, 1897.

Paralysis in Pott's Disease.—Partial or complete motor and sensory paralysis may develop in the course of vertebral caries. It may be due to the pressure of tuberculous material or to pachymeningitis with thickening of the membrane. In only 2 per cent. of cases of paralysis is the paralysis due to the pressure of angled bone (Willard). The paralysis may come on gradually. There are weakness in walking or actual inability to walk, exaggerated reflexes, muscular rigidity, and impaired sensation in the legs, and loss of control of the bladder and rectum. Caries in the high dorsal region is more apt to result in paralysis than in any other region, because of the small size of the canal. Pressure in the cervical region is highly dangerous.

Treatment.—We must remember that angulation is the rare cause, tuberculous masses the common cause. Treatment for paralysis due to tuberculous masses is the full open-air treatment of tuberculosis, with rest, fixation, and progressive straightening of the spine. The patient is kept in bed (see Treatment of Tuberculosis, page 226) on a Bradford frame and with his head overextended (Willard). If after one year the condition is not notably improved, do laminectomy and clear away tuberculous masses. If angulation is the cause of the paralysis, we consider gradual correction, forcible correction, and laminectomy.

Gradual Correction of Angular Deformity.—Pressure is made upon the hump with the hand, and while the hand is thus held the weight of the body is allowed to bear upon it above and below. Something is perhaps gained and then plaster-of-Paris is applied, somewhat later a little more gain is obtained, and so on. This method is safer and more satisfactory than forcible correction.

Forcible correction of angular deformity is advocated by Chipault and Calot in cases of Pott's disease without abscess. Forcible correction is only used, if used at all, in angular deformity of the middle and lower part of the dorsal region. It is not used in the cervical, upper dorsal, or lumbar regions. Before it is used a skiagraph should be taken, to show if bony ankylosis exists or if there is an abscess. If there is an abscess, it must be treated surgically, and must heal before forcible correction is attempted. If bony ankylosis exists, it must not be broken down. Only recent cases are suited for this treatment, and only cases in which very few vertebræ are involved (Gabaert). The operation is unjustifiable if any organs are tuberculous, and if a patient is in very poor health. It is said by its advocates to be particularly indicated when the deformity interferes with respiration or digestion, or when there is paraplegia, especially if paraplegia is due to disease of the mid-dorsal region. The advocates of the operation claim that it does not injure the cord or its membranes. The operation is not entirely safe, and a number of deaths have been reported. Chloroform must not be given, as it seems to possess special dangers in this condition. Gabaert * points out certain disasters which may follow forcible correction; they are: death during anesthesia; rupture of an abscess; subsequent paralysis of the legs and bladder; disseminated tuberculosis; and shock with convulsions and death. Forcible correction can be carried out as follows: the patient is anesthetized with ether and is placed face down; one assistant holds the feet, another the head, another supports the abdomen, and another the pelvis. While strong traction is made on the head and feet the surgeon

* Ann. de la Soc. Belge, July 15, 1898.

makes *forcible* pressure on the projection. After the correction of the deformity a plaster-of-Paris support is applied so as to include the neck, trunk, and pelvis, the site of the gibbosity being left exposed in order to avoid ulceration. A plaster-of Paris support is used for at least six months. After forcible correction a large gap exists, and this does not fill up with bone, but with dense fibrous tissue, and in some cases the spines and laminæ ankylose. When the support is first removed, there is usually a reappearance of the deformity to some degree. In some cases Cabot resects the spines and laminæ of the diseased vertebræ, and performs osteotomy of the ankylosed vertebral bodies.* Personally I do not believe in forcible correction and I do believe that the alleged dangers are real dangers and that the operation is unsafe.

Laminectomy is warmly advocated by some surgeons for paraplegia from spinal caries. This operation is rarely necessary, but in some few cases is imperatively demanded. Many cases recover from paraplegia without operation—operation in these cases has a very heavy mortality (25 per cent.); and many are not benefited at all by it. If degeneration of tracts in the cord has occurred, operation cannot help the paralysis. Nevertheless, in some cases laminectomy has certainly cured palsy and saved life.

Laminectomy should not be undertaken until treatment by rest and fixation and extension has been applied for at least one year. Laminectomy may become necessary in cervical caries to prevent asphyxia. The operation enables the surgeon to remove masses of inflammatory material which make pressure on the cord, and also to free the cord from pressure due to angulation. The dura should not be opened unless there is evidently trouble beneath it, in which case it is incised and any tuberculous area removed, the dura being subsequently sutured. Ménard removes the transverse processes of the diseased vertebræ and the heads and necks of the associated ribs in order to give the surgeon access to diseased vertebral bodies.

Spondylitis Deformans (*Bechterew's Disease*).—This is the name usually applied to osteoarthritis of the spine (page 567). In this disease osteophytic formation takes place at the vertebral borders, and the vertebræ become ankylosed. The vertebral bodies, as a rule, are most affected by the disease, but any portion of a vertebra may be attacked, and often the heads of the ribs are anchored to the spine by bone.

The disease may begin in infancy, childhood, youth, adult life, or old age.

Symptoms.—There are decided and persistent pain and tenderness of the spine, and occasionally evidence of pressure on the nerve-roots. Early in the case deformity is apt to occur, because at this period there is inflammatory softening.† The deformity is not angular, but is usually a total kyphosis, the column being bent forward from above and made into a single curve. Lateral curvature may occur. In many advanced cases and in some comparatively recent cases the spine becomes rigid and ankylosed, and when it does, there may be evidences of irritation of the posterior nerve-roots. In this condition there is rigidity of part or of the entire spine, other joints escaping. If the entire spine is involved, there is rigid cervico-dorsal kyphosis, a condition which causes the neck to stick forward and the head to appear as if forcibly driven down between the shoulders. If the entire spine is involved, the lumbar spine is rigid and the normal lumbar curve dis-

* F. Cabot, in Archiv Prov. de Chirurgie, Feb., 1897.
† J. Jackson Clarke's book on "Orthopedic Surgery."

appears. As a consequence the patient stands in an unnatural attitude, the hips and knees being partly flexed, and the legs and feet being in a condition of external rotation. In Bechterew's disease there are compression of the posterior nerve-roots, severe pain, muscular atrophy, and ascending degeneration of the cord. What Marie calls *spondylitis rhizomelique* is said by Osler to be a form of arthritis deformans. There is rigidity of the spine, shoulders, and hips, but no nervous lesions, as in Bechterew's disease.

Treatment.—Cure is impossible, but amelioration can be obtained.

The local and constitutional treatment is as for osteo-arthritis in any region (page 569). If curvature begins, a mechanical support must be applied.

Injuries of spinal ligaments and muscles, which may complicate more serious injuries or may exist alone, are caused by wrenches, twists, and violent muscular efforts (as in lifting). Railway accidents may be responsible for these sprains and strains. The injury is called "*railway spine*" when it is caused by a railway accident.

Symptoms.—Injuries of the back, even without cord-injury, are frequently linked with very deceptive nervous symptoms. Symptoms are often severe, but are usually temporary. In some few cases the symptoms are persistent. Secondary disease of the cord is extremely rare. Any region may be affected, but the lumbar is most usually injured, and the entire spine may suffer. The three marked symptoms are pain, tenderness, and stiffness of the back. At the time of injury, and for a while after, there is often marked shock, and hysterical excitement is occasionally observed. The cardinal symptoms may arise very soon, but may not become severe for a day or two. The pain is not acute when at rest, but becomes acute on movement.* The pain is felt in the back, and sometimes darts into the extremities. The muscles of the back are rigid, the spasm being due to pain. The patient is very careful not to twist or bend the spine, because to do so increases pain. In a one-sided injury the rigidity is unilateral, and this symptom cannot be simulated. Often, but by no means always, the region of the back is swollen and the skin is discolored. The tenderness is not of the skin, but of the muscles. Firm pressure on a spot of real tenderness causes rapid pulse (Mannkopff). The vertebral spines are regular and are not mobile. There is no distant paralysis or hyperesthesia unless the cord is damaged (though in some rare cases the bladder and the rectum are paralyzed when no cord-lesion can be detected, and hyperesthesia may exist over the spines). Moullin tells us that the extremities feel weak because they are deprived of proper support on account of the immobility of the muscles of the back. For the same reason the action of the abdominal muscles is interfered with, and the power of micturition and of defecation is impaired (there are constipation and difficulty in emptying the bladder).

The **treatment** of recent injuries comprises rest, the application of an ice-bag, and leeching over the painful area. After a day or two hot fomentations, tincture of iodin, compression by adhesive strips, and inunctions of ichthyol and lanolin are used; and, later still, massage, douches, and frictions with a stimulating liniment are employed. Phenacetin helps to relieve pain, though in some cases opium is necessary.

* Moullin on "Sprains."

Traumatic neurasthenia is apt to arise after the *immediate* effects of the accident subside. In this condition the patient grows tired easily and complains of pains and aches in the back and loins, interfering with or preventing work; paresthesia and numbness exist in the extremities; in many cases sexual intercourse is impossible because of premature ejaculation or of incapacity for erection; there are dyspepsia, eye-strain, insomnia, loss of memory, rapid and irregular pulse, cardiac palpitation, and mental depression or confusion. The reflexes are usually exaggerated, but they can be exhausted more easily than can the exaggerated reflexes of organic cord disease (because of irritable weakness). Some rigidity and tenderness exist in the back, and the skin over this region is often hyperesthetic. Attacks of retention of urine may occur. Hypochondriasis is not unusual.

Treatment of Traumatic Neurasthenia.—Employ rest, tonics, massage, douches, and frictions to the back. Secure sleep, and endeavor to bring about a gain in weight. If sexual incapacity or seminal emissions worry the patient, dilate the urethra with steel sounds.

Traumatic hysteria develops only in those predisposed by a neuropathic hereditary tendency; traumatic neurasthenia may arise in any one. In the first-named disease the accident is only the *exciting* cause; in the second disorder it is *the* cause. Many cases of so-called "railway spine" are really examples of traumatic hysteria. Traumatic hysteria and neurasthenia may be associated. Neurasthenia is a condition of exhaustion associated with a number of chronic disorders; it forms a foundation on which hysteria is apt to build its structure. The structure of hysteria is made up of morbid impressionability, hyperesthesia of centers, lowered self-control, and sensitiveness of the peripheral nervous system. The accident plays a double part in producing traumatic hysteria—first, by its effect on the mind (psychical traumatism); second, by its effect on the body, which anchors the attention to one point. An area of pain or stiffness often serves as an autosuggestion which undergoes morbid magnification when viewed through the distorting medium of hysteria. Erichsen taught that the symptoms of what he named "railway spine" arose from inflammation of the cord and its membranes, a view now abandoned. A blow given to a hysterical person causes a feeling of numbness, and thus negative sensation from local shock may establish the idea of paralysis, or traumatism, acting as a suggestion, may inhibit motor representations and destroy the normal ideas of motion and feeling (Charcot and Pitre). Terror always causes a feeling of loss of power in the legs, and the terror of the accident may thus develop the idea of paraplegia. The site of a traumatism may localize symptoms; for instance, a blow upon the eye may cause amaurosis or blepharospasm. It is important to remember Charcot's saying that a hysteria long latent and unrecognized may be awakened into obvious activity by a blow or an accident. Pitre shows the same to be true of epilepsy. A not unusual lesion is hysterical traumatic monoplegia, not coming on at once after the accident, but usually some days afterward, and presenting flaccid muscles, the electrical reactions and reflexes remaining normal, but the muscular sense being lost (Pitre). The muscles usually waste. The skin of the paralyzed limb is anesthetic or analgesic. There may be anesthesia limited to a limb, hemianesthesia, or general anesthesia.* Hysterical paralysis is usually associated with the

* J. Mitchell Clarke, in Brain.

permanent *stigmata of hysteria*—concentric contraction of the visual field, pharyngeal anesthesia, convulsive seizures, and hysterogenic zones (Clarke and Pitre). The permanent stigmata may be latent. Hysterical phenomena lack regularity of evolution, and they may be produced, altered, or abolished by mental influences or by physical forces which produce no effect on organic disease. In most hysterical conditions the general health is not profoundly impaired.*

Treatment.—By moral means chiefly. Gain the confidence of the patient. In many cases separation from family and friends is necessary and isolation is desirable. The Weir Mitchell rest-cure is the best plan of treatment, and all its details should be carried out faithfully.

Malingering.—Persons often pretend to suffer from maladies of the spinal cord or column as a result of accident, which diseases do not exist in them. Some get well upon the rendering of a favorable verdict by a jury (**litigation backs**). In any case always examine carefully, so as to be able to exclude malingering. Note the patient's behavior and motions when his attention is diverted from his disease. *Meningomyelitis* can be excluded if there be no spasm, paralysis, hyperesthesia, paresthesia, or anesthesia at a distance (A. Pearce Gould). If pain has lasted for months; if pressure downward upon the head or shoulders does not increase pain; if the vertebræ are movable and there is no angular displacement, exclude *caries*. Gould states that when there are wasted muscles, when moderate spine movement is painless, but effort in bringing the body erect causes pain in the erector spinæ region, the trouble is a *strain of the erector spinæ muscle*. If the muscle is not wasted and the pain is in bending forward rather than in straightening up, the *vertebral ligaments* are the seat of trouble. Unilateral spasm cannot be simulated. The administration of ether may dispose of a pretended paralysis, the patient moving the suspected extremity while drunk from the anesthetic.

Concussion of the Spinal Cord.—This term has no definite pathological meaning. It is probable that the condition is one of laceration of capillaries and of cord-substance.

The **symptoms** are shock, intense pallor, nausea, often vomiting, and sometimes syncope. With this condition special symptoms may be linked—as temporary paralysis, a girdle-sensation, numbness and loss of power in the limbs, hiccough, torticollis, coarse tremors, pains in the back and limbs, areas of anesthesia and analgesia—depending on the portion of cord lacerated.

Treatment.—The treatment in concussion of the spinal cord is the same as that for sprains. Traumatic neurasthenia and hysteria or organic cord-disease may follow this injury.

Contusion of the spinal cord may arise from a blow or a sprain, but it is usually due to extreme flexion of the spine. It causes hemorrhage into the gray matter of the cord (*hematomyelia*). The symptoms are motor and sensory palsy and diminished reflexes. Some cases recover, but others end in myelitis.

Wounds of the spinal cord are rare, and are usually fatal. Wounds above the origin of the phrenic nerves cause almost instant death. Gunshot-wounds are the most usual form, the cord being damaged by the bullet and by bone-fragments. A knife is sometimes thrust in between the occiput and atlas.

* Read the works of Thorburn and Pitre.

Treatment.—In a suspected wound of the cord do an exploratory laminectomy, arrest hemorrhage, and if the cord is divided, suture it.

Compression of the spinal cord may be due to blood or to inflammatory exudate, as well as to displaced bone (page 757). *Compression from blood* may be due to *extramedullary* hemorrhage or to *intramedullary* hemorrhage. *Extramedullary* hemorrhage causes sudden pain in the back, the pain radiating from compressed nerve-roots; hyperesthesia and paresthesia in the area of the radiated pain; spasm of vertebral muscles supplied by the compressed nerves, sometimes of muscles whose nervous supply is below the lesion; tremors; convulsions; retention of urine; paralytic symptoms following the signs of irritation, but no absolute paralysis (Mills). A girdle-sensation is usual. *Intramedullary* hemorrhage causes pain, a girdle-sensation, abolition of reflexes, and paralysis. Spasms, rigidity, and paralysis come on early. Bedsores may form, and retention of urine and incontinence of feces may be observed. Paralysis from hemorrhage is rapidly progressive from below upward (crawling paralysis).

Treatment.—If paralysis from spinal-cord bleeding extends rapidly and life is endangered through the probable involvement of a vital center, perform a laminectomy, remove the clot, and arrest the hemorrhage. It is wise always to open the dura and inspect the cord. Extramedullary hemorrhage may be arrested by sutures or by packing. Intramedullary hemorrhage may be arrested by suture-ligatures or by packing. If an extramedullary clot is extensive, it is proper to make a second laminectomy near the lower end of the spinal column in order to permit the surgeon to wash it out thoroughly. The dura must be sutured and drainage is to be employed. If there is paraplegia, complete anesthesia of the paralyzed parts, and entire abolition of the deep reflexes, operation is probably useless, but it is justifiable to try it because of a possibility that the cord is not completely divided. In some cases with persistent paraplegia the operation should be undertaken. If operation is not undertaken, have the patient lie upon his side, apply a spinal ice-bag, and give morphin hypodermatically. If hemorrhage continues in the cord and if the patient be plethoric, perform venesection. To promote absorption of the clot and exudate give a combination of carbonate and acetate of ammonium, order pilocarpin, and employ spinal galvanism and hot douches (Bartholow).

Fractures and dislocations of the spine are very rare. The spinal regions most liable to injury are the atlo-axial, the cervicodorsal, and the dorsolumbar (Treves). A vertebra may be fractured alone, but dislocation without fracture, except in the upper cervical region, very rarely occurs. These two lesions, dislocation and fracture, are so often associated that the term *fracture-dislocation* is used by many surgeons to include them both. The **causes** of fracture and dislocation are direct force (seldom) and indirect violence (commonly). Forced flexion or overextension is the commonest cause. In fractures from indirect force the cord generally suffers. In some cases the displacement of the vertebra lacerates the cord, the vertebræ return into place, and no deformity is detectable. Fracture-dislocation from direct force may occur at any part of the column, and in this accident the posterior vertebral segments are driven together, and the cord, as a rule, escapes injury. Fracture-dislocations from indirect force most commonly

happen in the cervical and dorsal regions. In the cervical region reduction can usually be secured, but in the lumbar region reduction is impossible.

Symptoms.—In fracture-dislocation great displacement is unusual, but some is almost always recognizable (irregularity of the spines or angular deformity). There are pain (which is increased by motion), tenderness, ecchymosis, and motor and sensory paralysis. Priapism, cystitis, and retention of urine often occur. Horsley has pointed out that in many cases paralysis passes away only to recur subsequently, the recurrence being due to edema of the cord. In some cases of spinal injury there is *temporary paralysis* due to *shock*. *Persistent paralysis* may be due to laceration of the cord, division of the cord, or compression of the cord by bone, blood-clot (Fig. 422), or products of inflammation. The extent of paralysis depends on the seat of the cord-injury. We must always try and decide if the spinal cord is completely divided or hopelessly crushed (Fig. 421). When the symptoms are not immediate in onset; when all the muscles below the seat of injury are not completely paralyzed; when there is some retention of sensation; when reflexes are present and muscular rigidity exists, we may be sure that the cord is not completely divided. When the cord is completely divided, the symptoms are immediate, there are absolute flaccid motor paralysis and complete sensory paralysis (loss of appreciation of pain, touch, and temperature). The line of anesthesia is definite and suddenly terminates (Walton). The bladder and rectum are paralyzed and there may be priapism. All the reflexes, superficial and deep, except perhaps the plantar, have disappeared. There is no pain, there are no muscular spasms, there is vasomotor paralysis with sweating of the paralyzed parts, and the symptoms persist and do not

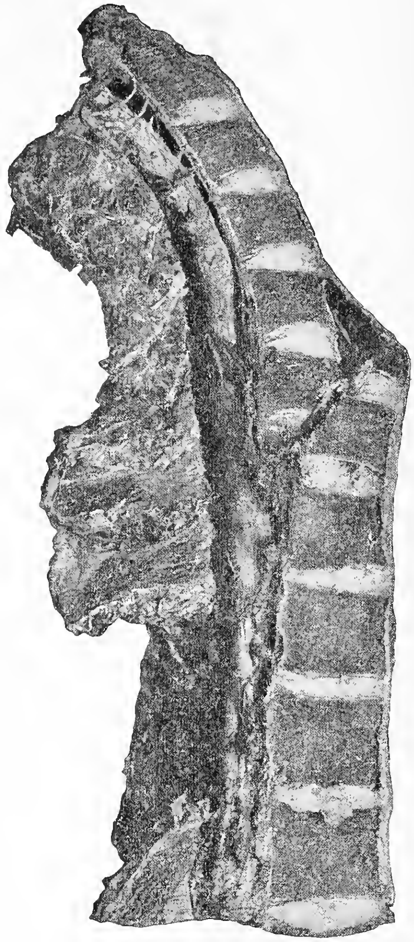


Fig. 421.—Spine sawed. Fracture of the spinous processes of the seventh cervical and first and second dorsal vertebræ. Fracture of the bodies of the fifth, sixth, and seventh cervical vertebræ with displacement *backward* of the upper fragment. Total crush of the cord. The section passes a little to one side of the cord, which is seen in place, and the staining of the cord by hemorrhage into its substance shows plainly through the membranes even in photograph. The spinous processes of the second and third dorsal vertebræ were found fractured at the operation, and were removed (Thomas).

vary (J. J. Thomas, in "Boston City Hospital Med. and Surg. Reports"). There is usually tympanites (Walton). If this latter symptom-group is due to shock, it will usually be temporary, but occasionally, even when so caused, it persists some considerable time. It is also probable that concussion of the cord may in some cases simulate complete division. As Walton says, no symptoms *prove* a hopeless crush of the cord: it is the persistence of the symptoms which does prove it ("Jour. Nervous and Mental Diseases," Jan., 1902); I would add the *unchanging persistence* of the symptoms proves it.

A. J. McCosh ("Jour. Amer. Med. Assoc.," Aug. 31 and Sept. 7, 1901) points out that definite pressure is indicated by marked symptoms and absence of reflexes. When there is not definite pressure, the symptoms are irregular; there is incomplete palsy, or muscles of the same group show different degrees of paralysis; anesthesia is partial; signs of irritation are not distinct, and there are patches of hyperesthesia and zones of paresthesia. If in doubt, at the end of twelve hours perform an exploratory operation.

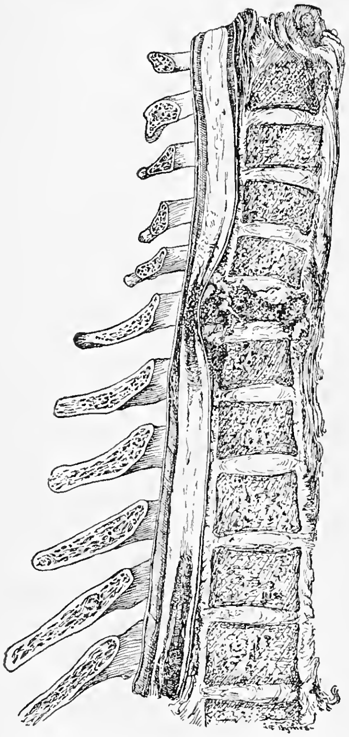


Fig. 422.—Fracture of the cervical spine; cord compressed by bone and blood. Hemorrhage into the cord at the seat of the lesion and below the lesion (Warren Museum) (from Scudder's "Treatment of Fractures." Drawn by Byrnes).

The **prognosis** depends on the amount of damage done to the cord. Fracture-dislocations in the cervical region produce obvious deformity, stiffness of the neck, and irregularity of the spines, and a displaced vertebra may occasionally be detected by a finger in the pharynx. Crepitus can rarely be detected unless a spinous process is fractured. The Röntgen rays aid diagnosis. The seat of cord-injury may be determined by a study of the palsy and other symptoms.

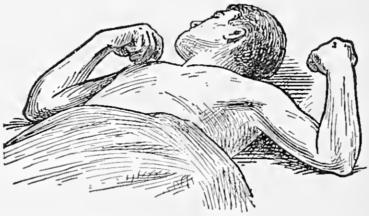


Fig. 423.—Lesion of spine between fifth and sixth cervical vertebræ. Note position of arms, due to paralysis of subscapularis. Biceps anticus, supinator longus, and deltoid muscles intact. Elbow flexed, shoulders abducted and rotated outward (after Thorburn).

Fracture-dislocation of the atlas or axis usually causes instant death. When the displacement is only trivial, the patient may actually recover, but will probably die of secondary cord-disease. In injury of the third cervical vertebra the phrenic nerve is involved, the diaphragm is paralyzed,

and death soon occurs. In fracture-dislocation of the fifth cervical vertebra the subscapularis muscles are paralyzed, but the biceps, brachialis anticus, supinator longus, and deltoid escape, and the patient assumes a characteristic attitude (Fig. 423). In Jones's case of fracture of the fifth cervical vertebra no operation was performed, but the patient partly recovered and became able to walk, but with a spastic gait ("Lancet," Nov. 28, 1903). If the sixth vertebra is dislocated, there is palsy of the muscles of the hand. In injuries below the sixth vertebra no muscle of the arm, forearm, or hand is paralyzed at first, although after some days paralysis may develop. Damage to the cord above the sixth cervical vertebra produces anesthesia of the body below the injury and of the entire upper extremity except the shoulder. In injury just above the upper level of the seventh cervical there are body-anesthesia and anesthesia of the outer surfaces of the arms and ulnar margins of the forearms and hands. In any cervical injury there are body-anesthesia and diaphragmatic respiration, and in cases without paralysis of the arms there is sure to be pain. Injuries of the dorsal spine can be accurately located. There is paralysis of motion and sensation up to, or almost up to, the seat of injury. The arms are not paralyzed. Very great pain in the legs occurs if the lumbar enlargement is involved. In injury of the twelfth dorsal or upper lumbar vertebra there are paralysis of the bladder and rectum, an incomplete anesthesia, and a partial motor paralysis of the limbs.

Treatment of Fracture-dislocations.—When dislocation of the body of the vertebra obviously exists, the surgeon may attempt reduction by extension and rotation. The maneuver is very dangerous in the cervical region, and, as deaths have happened, some eminent surgeons advise against reduction when the injury affects that region. In fracture-dislocation the traditional plan is to straighten the spine, gently if possible, and to put the patient upon his back upon a water-bed or upon air-cushions. In fractures in the cervical region support the head and neck with sand-bags. Empty the bladder every six hours with a soft catheter, which is kept strictly aseptic. Take every precaution to prevent bed-sores. Some surgeons advocate reduction of the deformity by extension and counter-extension, and the application of a firmly fitting but removable jacket with the suspension collar (as used in Pott's disease). If this plan is employed, the head of the bed is raised and the collar is fastened to it. Every day extension is made gently—from the shoulders in dorsolumbar fracture, and from the chin and occiput in cervical fracures. Extension may be maintained permanently until cure. Surgeons have come rather slowly to a belief in laminectomy. One deterrent factor has been the high mortality: Lloyd collected the records of 159 operations and found that 59 patients died almost at once and 39 died later. Some employ purely expectant treatment in vertebral fractures. My own feeling is that when simply a spinous process or some other part is fractured, and there are no cord symptoms, we may treat the patient expectantly, following Burrell's advice and fixing the patient in bed on a Bradford frame and having him carefully nursed and watched. Reduction by extension and counter-extension is dangerous and unjustifiable if there is marked kyphosis and if cord symptoms exist. I agree with Burrell that it should only be done if operation is refused, or if there are no cord symptoms and no marked kyphosis ("Annals of Surgery," Oct., 1905). If it is attempted it must be done

slowly and as gently as possible because it may cause grave or even irreparable damage to the cord. I fear to delay, and, with Burrell, Lloyd, Walton, and others, operate when the patient recovers from shock, if there seems to be even a gleam of hope that operation may help him. To wait when pressure exists means that during every hour of delay the pressure is damaging the cord. Another reason for operating is that we cannot know the condition of the cord without direct inspection. The operation to be performed is laminectomy. As before stated, this is to be done even if we suspect division or hopeless crush of the cord. In some cases, it is true, we may commit the error of operating when there is only concussion, but such a mistake is less grave than to fail to operate when there is bone-pressure or hemorrhage. An objection filed by the neurologist against laminectomy is that portions of cord above and below the level of the fracture may be damaged (Fig. 422), but, as Lloyd says, this fact does not forbid operation, but renders it necessary to make a wider exploration than has been the custom. In many cases after prompt laminectomy we get some considerable improvement, and this improvement may be sufficient to enable a man to earn a living. It is true that statistics would indicate that late operations have been more successful than early ones, but these figures must be analyzed in the light of the knowledge that many of the fatalities after early operation would have occurred if no operation had been done, and some improvements after late operation would have occurred to as great or a greater degree after early operation. The prognosis of any operation, early or late, is never gratifying, and Thorburn feels no confidence in obtaining improvement except in injuries of the laminæ, hemorrhage, or injuries of the cauda equina, as he says laminectomy in the cervical region is followed by death, and laminectomy in the dorsal region, though not commonly fatal, is seldom followed by recovery of function. Our statistics of early laminectomy will show fewer deaths and fewer useless operations if we do not operate till shock abates. As Lloyd says ("Phil. Med. Jour.," Feb. 5, 1902): "It is therefore evident that if we operate immediately after the injury we will have failures that should not be charged against the operation itself, and, if possible, we should wait before operating until the question can be settled whether the patient will overcome the shock or will succumb directly to the effects of the injury." All surgeons operate for compound fracture, for hemorrhage, and for cases with marked bone-pressure. If early operation were not performed and if pachymeningitis arises, operation is called for.

My own convictions are that if symptoms are significant, we should explore, as soon as shock has passed away, even if we think it probable that the cord has been divided; and if it is found divided, it should be sutured. If in any case we are in doubt twelve hours after the injury as to whether or not pressure exists, we should explore. If soon after the accident we think pressure by bone exists, we should operate. If the case is improving, we should not operate even if there are pressure-signs, unless there is a chance that pressure is due to bone, in which case we should operate. As McCosh says, pressure by blood or inflammatory exudate may pass away; pressure by bone cannot. Even long after an injury laminectomy may be productive of some benefit.

The rather radical views set forth above regarding the advisability of

operating even if the symptoms point to complete division of the cord arose largely from a knowledge of the well-known case operated upon by Stewart for total division of the cord. In a case of gunshot-wound of the dorsal spine treated at the Pennsylvania Hospital by Francis T. Stewart, and reported by Francis T. Stewart and Richard H. Harte ("Phila. Med. Jour.," June 7, 1902), an exploratory incision made three hours after the injury showed that the spinal cord was completely divided. There was a fracture of the laminæ of the seventh dorsal vertebra. The spines and laminæ of the seventh and eighth dorsal vertebræ were removed. The bullet-hole was recognizable in the membranes, and the bullet and some bone-fragments were removed. When the dura was opened, the ends of the completely divided dorsal cord were found to be three-quarters of an inch apart. Stewart freshened these ends and brought them together with two sutures of chromicized catgut. In this case a considerable degree of restoration of function took place. At the time of the operation, three hours after the injury, there were complete paralysis and absence of reflexes below the seat of injury; but sixteen months later the patient was able voluntarily to flex the toes, flex and extend the legs, flex and extend the thighs, and, while sitting, lift an extended leg from the floor. The movements of the lower extremity became more forcible when reinforced by contracting the muscles of the upper extremity while making them. The patient could stand with one hand resting on the back of a chair, and could get herself from her bed to her chair by sliding. The bowels were under perfect control, and there was no incontinence of urine when she was awake, although there was occasionally some when she was asleep. There were occasional cramp-like pains in the lower limbs. The sense of touch, temperature, pain, and position were perfect all over the previously paralyzed parts. Below the knee the localization of sensation was not so accurate. There was a slight amount of muscular rigidity; and on each side, an ankle and patellar clonus, which was easily exhausted. When the sole of the foot was tickled, the big toe flexed, the thigh abducted, and there was slight contraction of the anterior tibial, the hamstring, and the tensor vaginæ femoris muscles. There were no reactions of degeneration and no trophic changes. There had never been any bed-sores. George Ryerson Fowler ("Annals of Surgery," Oct., 1905) operated on a gunshot-wound of the dorsal spine eleven days after the injury. He removed the laminæ of the tenth, eleventh, and twelfth dorsal vertebræ and found the cord divided, the bullet lying between the severed ends. A piece of dura one-eighth of an inch wide was intact. The bullet and blood-clot were removed. The cord was sutured with three sutures of chromicized gut, which included the dura, and more sutures were taken through the dura only. The ends of the cord were easily approximated. The patient recovered from the operation. Twenty-six months later voluntary motion was found to be practically lost in the area below the injury, although when supported by the hands he could stand and when in a frame could move a little by a swinging movement. He is able to tell when his bowels or bladder are about to move, and, if furnished promptly with a utensil, does not soil himself. When asleep, he passes urine involuntarily. Both legs exhibit spastic rigidity, but there are no reactions of degeneration. Patellar reflex on each side exaggerated. Ankle clonus is found on one side, but not on other. There is complete anesthesia of the affected area,

except in a region five inches in length on the outer side of the right thigh. Touch is appreciated but not correctly localized. In connection with the foregoing important cases we would note that Dr. Estes, of Bethlehem, has also operated upon a case of complete division of the spinal cord, in which suturing was followed by some restoration of function.

In the light of these positive reports we must ask ourselves if we have not been wrong in the view that the spinal cord cannot regenerate. If there is even a chance that we have been wrong, we must reverse our former conservative treatment and follow a radical plan. The three cases strongly suggest the possibility of some regeneration, but do not prove it. The cord may have appeared to be completely divided and yet minute undivided bundles may have escaped recognition. Again, as Fowler suggests, there may be a nerve anastomosis through uninjured portion of the dura or between adjacent nerve-trunks which arise above and below the lesion. At my request Dr. Samuel Lloyd, of New York, kindly wrote me a personal communication setting forth his views on this important subject. They are as follows: "The question of the regeneration of the spinal cord after traumatism of the spine deserves careful consideration in all cases that are operated upon. Up to the present time, however, although a number of operators have reported improvement following suture of the spinal cord in these cases, a careful analysis does not substantiate the fact that that improvement is due to an actual regeneration. It is a recognized fact on the part of all who have had experience with the surgery of the spinal cord that in almost every instance a certain amount of improvement is noted during the first few months. This is probably due to the fact that at the time of the injury minute hemorrhages occur into the adjoining segments, and that pressure is also increased in those portions of the cord by the inflammatory exudate and edema. Within a short time after the injury these conditions improve, and there seems to be an improvement in function; but in every case of spinal suture yet reported the amount of improvement may be explained by these facts. In no instance has there been a complete recovery of function, but in every one there has remained more or less permanent disability. This, however, should not discourage attempts at spinal suture, and in every case operated upon the dura should be opened and the condition of the cord examined. In those cases where a complete destruction has occurred and where the extent of it is not over three-quarters of an inch, it may be possible to cut out the lacerated portions and coaptate the surfaces by a series of sutures placed in the dura. In all these cases the patient should be put up in a plaster retaining bandage in extreme extension, even the head being thrown back so as to relax as much as possible the tension on the line of suture. The operator should be very sure, however, that there are no undestroyed fibers traversing the lacerated area, for the destruction of these in case regeneration did not occur would increase the amount of paralysis." With the views of Lloyd I am in entire agreement, and in future I shall follow this plan, bearing in mind that it is often impossible to tell whether the spinal cord is completely divided or seriously damaged without examining it, and it can be examined only by exploratory operation; therefore, if the serious symptoms already indicated exist after shock has passed away, exploratory operation should be performed; if pressure exists, it should be removed;

and if the spinal cord is found to be completely divided, it should be sutured. It is well to remember that Abbe's experiments have shown that there may be great difficulty in bringing the divided endsof the cord into apposition. In order to effect this it may be necessary to resect a vertebra.

Operations on the Spine.—Operation for Spina Bifida.—A. W. Mayo Robson maintains* that operation is not demanded when the sac is of small size and is well protected by sound integument; that operation is improper when a large portion of the column is fissured, or when paraplegia or hydrocephalus exists; that operation is advisable only in meningocele, in cases in which the integument is thin and translucent, in cases in which the cord is flattened out or the nerves are fused. Robson has closed the osseous defect by transplanting periosteum.

Instruments Required.—Scalpels, dissecting and hemostatic forceps, scissors, mouse-toothed forceps, rongeur forceps, dural separator, Hagedorn needles and needle-holders, silk, silkworm-gut or catgut.

Operation.—Surround the sac by elliptical incisions. Find the neck of the sac, and if it contains no visible nerves, ligate it and cut off the protrusion. Push the stump into the canal. Freshen the bone-margins and spring a piece of celluloid beneath them to close the gap (Park). Suture over the stump with small sutures of catgut.†

Treves's Operation for Vertebral Caries.—(See page 618.)

Laminectomy.—The instruments required for laminectomy are dissecting, mouse-toothed, and hemostatic forceps; scalpels; bone-cutting forceps; rongeur forceps; a dry dissector; a periosteum elevator; sequestrum forceps; small scissors, straight and curved on the flat; a chisel and mallet; retractors; blunt hooks; a probe; tenaculum forceps; a spoon-curet; a sand-pillow; fine needles, curved and straight, large needles, and a needle-holder.

In the *operation* of laminectomy the patient lies prone and a sand-pillow is placed under the lower ribs. Make a vertical incision over and down to the vertebral spines, the middle of the incision corresponding to the seat of injury or disease. The sides of the spinous processes and the laminæ are cleared. The periosteum is incised in the angle between the laminæ and spines, and is lifted away from the arches. The spinous processes are cut off close to their bases by means of rongeur forceps, the laminæ are removed on each side with the rongeur, and the dura is exposed. In some cases of fracture fragments will be found on exposing the vertebra, or a blood-clot will be seen between the dura and the bone; in other cases the dura must be opened with scissors vertically in the middle line while it is grasped with mouse-toothed forceps. After reaching and removing the compressing cause, or after failing to find or remove it, it is best not to close the dura completely, because if we do so, cord pressure may result from hemorrhage. The dural wound is partly closed and a drain of rubber tissue is carried down to the opening. The superficial parts are stitched with silkworm-gut and dressings are applied.

Puncture of the spinal meninges, or **lumbar puncture,** was devised by Quincke, and has been carefully tested by many surgeons (Fürbringer,

*Annals of Surgery, vol. xxii, No. 1.

†A full consideration of the various plans of operating will be found in an article by Marcy, in Annals of Surgery, March, 1895.

Naunyn, and others). It is the operation for withdrawing cerebrospinal fluid from the subarachnoid space of the cord. It is employed as a means of diminishing cerebral pressure in hydrocephalus, cerebral tumor, uremia, and tuberculous meningitis. It has proved of little therapeutic value. It may be of some service in cerebrospinal meningitis. In the performance of a brain operation the brain may bulge so that the dura cannot be sutured. Lumbar puncture makes suturing possible. In some cases the examination of the fluid has been of great diagnostic value. The fluid is not only subjected to a naked-eye study: it is also studied microscopically and bacteriologically. If the fluid from the puncture gives no positive finding, the operation should be repeated (Lorgo). Normally the fluid is clear, and under a pressure of from 40–60 millimeters of mercury (Dana) the specific gravity is from 103–104. The study of the cerebrospinal fluid and its contained cells is known as *cyto-diagnosis*. Stadelmann has reported 37 cases in which tubercle bacilli were found in the fluid.* In tuberculous meningitis the fluid may or may not contain tubercle bacilli, but it probably contains sugar and practically always an excessive number of polymorphonuclear leucocytes. Turbidity of the fluid indicates the existence of meningitis. In cerebrospinal meningitis the cerebrospinal fluid contains the meningococcus. In this disease lumbar puncture is unnecessary if the nasal mucus contains the diplococcus intracellularis. Bloody fluid indicates hemorrhage within the arachnoid of the brain or cord. This finding is of great importance in cerebral hemorrhage of the new-born and in suspected fracture of the base of the skull. The diagnosis of basal fracture is confirmed by the evacuation of bloody fluid in a lumbar puncture. Sometimes after a lumbar puncture the symptoms depending on a basal fracture are distinctly though temporarily relieved: violent pain always disappears (Terrier). The operation of lumbar puncture is simple, and if done with proper precautions, is harmless. The back should be carefully sterilized and thorough asepsis must be preserved in every detail. The patient may lie on the right side with the left knee well drawn up, may lie prone, with a pillow under the belly, or may sit in a chair, with the body bent forward. The site of the intended puncture may be frozen with ethyl chlorid, but no general anesthetic is required. A Pravaz syringe is employed. The needle, which should be 3 inches in length, is guarded by the surgeon's index-finger and the point is inserted one-half an inch to the right of the median line and between the third and fourth lumbar vertebræ (Mallory and Wright). It is pointed upward and a little inward under a spinous process. In a child the needle enters the canal at a depth of from 2 to 3 centimeters; in an adult, at a depth of from 4 to 6 centimeters. The fluid is permitted to fall drop after drop into a sterile test-tube. In some cases but a few drops of fluid will be obtained; in other cases many cubic centimeters may be removed. It is not wise to draw over 5 c.c. from a child and 10 c.c. from an adult. If we evacuate too much cerebrospinal fluid, the ventricles are emptied and compression of the cerebellum may arise. The flow should be spontaneous, and suction ought not to be used. Sometimes nausea, vertigo, and severe headache follow the operation, and sudden deaths have been reported. For a number of hours after tapping the patient should remain recumbent.

* Berliner klinische Wochenschrift, July 8, 1895.

XXV. SURGERY OF THE RESPIRATORY ORGANS.

Diseases and Injuries of the Nose and Antrum.

Foreign bodies in the nose are usually introduced through the anterior nares, but in rare instances they enter by way of the posterior nares. Small particles are often expelled spontaneously; larger pieces collect mucus and epithelium and become fixed. Some materials swell after lodgment.

Treatment.—In many cases anesthesia is required. Illuminate the nostril, and, if the foreign body can be seen, insert a hook back of it and effect its removal by means of forceps. Some foreign bodies require to be pushed back into the nasopharynx. Occasionally expulsion may be effected by inserting a rubber tube into the unblocked nostril and telling the patient to blow forcibly through the tube. In serious cases a specialist should be summoned to remove a portion of the turbinated bone or to perform whatever operation he thinks best.

Inflammation and Abscess of the Antrum of Highmore (**of the Maxillary Antrum**).—The source of this disease may be inflammation of the nose or periostitis around the roots of the teeth. In some cases the natural opening into the meatus is patent; in other cases it is partly or completely blocked. Caries and necrosis may arise. The **symptoms** are pain, edematous swelling of the face, and thinning of the bone so that it may crepitate under pressure. When pus has formed, if the antral opening is patent, certain positions of the head will cause a purulent flow from the nose, and if a speculum is inserted pus may be seen as it flows into the nose. The opening of the maxillary antrum into the nasal channel is at the summit of the antrum; hence the antrum drains when the head is inverted. The ethmoidal cells and frontal sinus drain best when the patient is upright. Wipe the interior of the nose and place the patient with his head between his knees. If the nostril fills with pus, it comes from the antrum (Cobb). In severe cases the jaw expands, the eye protrudes, and great tenderness of the alveolus exists. Percussion exhibits a dull note. In making a diagnosis it is well to take the patient into a dark room, insert an electric light into the mouth and note the diminution of light-transmission on the diseased side as contrasted with the sound side. Transillumination may be easily practised by the use of a cautery electrode, protected by a small glass vial. Any cautery battery may be employed (plan suggested by Ohls). Exploratory puncture will settle a doubtful diagnosis. This may be by way of the lower meatus, the canine fossa, or the alveolar process.*

Treatment.—Before pus forms order the use of hot fomentations and remove any diseased teeth. When pus has formed, evacuate it at once. Before performing a severe operation try the effect of opening into the antrum from the nose, by means of Krause's trocar, followed by insufflation of iodoform. If this procedure fails, other means may be employed. If the disease arises from a carious tooth, pull the tooth and push a trocar through its socket into the antrum. If the teeth are sound,

* Cobb, in Boston Med. and Surg. Jour., May 7, 1896.

bore a hole with a large gimlet or with a bone-drill above the root of the second bicuspid tooth and one inch above the edge of the gum. A counter-opening should be made into the inferior nasal meatus. A drainage-tube is pulled from the first opening into the nose and is allowed to protrude from the nostril. Irrigate daily with normal salt solution. In three or four days discontinue through-and-through drainage, but prevent the first opening closing until the discharge ceases to be purulent. In severe cases make a free incision through the canine fossa by means of a chisel.

Distention and Abscess of the Frontal Sinus.—The usual cause is an injury which may long antedate the symptoms. This injury causes or leads to blocking of the infundibulum; secretion accumulates and distends the sinus; and in some cases pus forms. In many cases the fluid slowly accumulates, and it requires years to produce marked symptoms. In other cases infection takes place, and the symptoms are positive and violent. If the outlet into the nose is not permanently blocked, the fluid may discharge itself from time to time. In the chronic cases there is rarely much pain. The chief sign is a swelling of the inner or upper part of the orbit, which swelling progressively increases and finally displaces the eye. If at any time acute symptoms supervene, there will be pulsatile pain, discoloration, and tenderness.

Treatment.—In some cases it is possible to pass a trocar upward from the nose into the sinus, and so drain and irrigate. In most cases an incision should be made through the soft parts, and the sinus opened by a trephine or chisel. After the sinus has been opened it must be curetted. The opening into the meatus should be restored and enlarged, and a drainage-tube must be passed from the forehead incision into the nostril. I usually prefer to open the sinus by making an osteoplastic flap in the anterior wall.

Diseases and Injuries of the Larynx and Trachea.

Edema of the Larynx (Edema of the Glottis).—The **causes** of edema of the larynx are: acute laryngitis; chronic diseases, such as tuberculosis, malignant disease, or syphilis; inflammatory disorders, such as diphtheria and erysipelas; acute infectious diseases; Bright's disease; aneurysm; whooping-cough; pneumonia; quinsy; wounds of the larynx; wounds of the neck; scalds and burns of the larynx, and the inhalation of irritating vapors, such as those of ammonia and sulphur. The **symptoms** are sudden and rapidly increasing dyspnea, respiratory stridor, huskiness of the voice, and finally aphonia. The swollen epiglottis may be felt with the finger and may be seen with the help of a mirror.

Treatment.—In cases in which edema of the larynx is not excessively acute, introduce a gag between the teeth, hold the mouth open, take a knife wrapped to within one-quarter of an inch of its point, make multiple punctures into the epiglottis, and favor bleeding by the inhalation of steam. In severe cases perform intubation or tracheotomy.

Wounds and Injuries of the Larynx.—The larynx may be injured internally by foreign bodies, and externally by blows and cuts. A condition often met with is *cut throat*, the result usually of a suicidal attempt on the part of the patient or a homicidal effort on the part of an assailant. The cut of the suicide is usually in front; as a rule, it misses the great vessels, but divides the

cricothyroid or thyrohyoid membrane. The epiglottis may be incised, or even be cut off. If a large vessel is cut, death rapidly occurs. The immediate dangers of cut throat are hemorrhage, suffocation by blood in the windpipe and bronchi, or by displacement of parts, and entrance of air into veins. The secondary dangers are pneumonia, infection and sepsis, exhaustion, and secondary hemorrhage. The remote dangers are stricture and fistula (Keetley).

Treatment.—In wounds of the throat arrest hemorrhage, remove clots from the larynx and trachea, bring about reaction, asepticize the parts as well as possible, suture the deeper structures with silver wire, catgut, or kangaroo-tendon, and the superficial parts with silkworm-gut, dress antiseptically, and place a bandage around the head and chest so as to pull the chin toward the sternum. If laryngeal breathing is much interfered with, perform tracheotomy. Feed the patient through a tube until union is well advanced. The old method of leaving the wound open is to be condemned. When sutures are used, primary union may be obtained. This fact was proved by Henry Morris.

Scalds of the Glottis.—(See section on Burns and Scalds.)

Foreign Bodies in the Air-passages.—The lodgment of foreign bodies in the air-passages is a frequent accident. Small solid bodies are usually expelled by coughing. Liquids and solids rarely pass beyond the larynx (except in laryngeal disease or palsy, wounds of the floor of the mouth, cut throat, and in people unconscious or very drunk). In vomiting during or after the administration of an anesthetic, or in the vomiting of drunkards, the vomited matter may find its way into the larynx or lungs. There is great danger of this accident in an operation upon a patient with intestinal obstruction who has stercoraceous vomiting. In most instances of foreign bodies lodged in the air-passages it will be found that the object was being held in the mouth when a sudden deep inspiration was taken (often during laughter). The **symptoms** are *immediate*, due to obstruction by the body and to spasm, and *secondary*, due to the situation of the body and the changes it undergoes or induces.

Lodgment in the pharynx causes violent dyspnea. The body can be seen or felt.

Lodgment in the Larynx.—In a severe case the patient fights madly for air; his face becomes livid and cyanotic; his veins stand out prominently; speech is impossible, though he may make noises and utter harsh cries; violent coughing begins, and then vomiting; he tries to force a finger down his throat and clutches at his neck; sweat pours from him; he feels a sense of impending dissolution, and he falls unconscious, with incontinence of feces and urine.* In a less severe case violent dyspnea gradually departs and the patient lies exhausted; but dyspnea and cough are liable to recur suddenly at any time because of spasm, and they may be induced by a change of position. These attacks of fierce spasmodic cough are not at first linked with expectoration, but after inflammation begins there is a profuse and often bloody expectoration. Inflammation follows more rapidly the lodgment of a sharp or irregular body than it does that of a round or smooth body. Inflammation is apt to produce edema of the glottis, bronchopneumonia, or ulceration and necrosis of the larynx. Any sort of foreign body in the larynx may at any moment produce

* See Moullin's graphic description in his "Treatise on Surgery."

spasmodic dyspnea, and is always very liable to cause edema of the glottis. The body if bony or metallic can be detected by the x-rays.

Lodgment in the Trachea.—The immediate symptoms of a foreign body in the trachea depend on the shape and weight of the body, and whether it becomes fixed in the mucous membrane or moves to and fro with the air-current. A smooth, heavy body falls to the tracheal bifurcation, and, if it does not enter a bronchus, moves with every breath, and by its movement causes violent laryngeal spasm, cough, and whooping inspiration without aphonia. The patient is often conscious of the movements of the foreign body, and the surgeon may detect them with the stethoscope. The foreign body may be found with the Röntgen rays. A foreign body in the trachea is liable to cause death by dyspnea, or it may ascend so as to be caught in the larynx, or may even be expelled. Irregular or sharp bodies lodge in the mucous membrane, produce inflammation, frequent cough, and expectoration, and finally lead to ulceration. Bodies which swell from heat and moisture tend to lodge and to become fixed (seeds may sprout).

Lodgment in a Bronchus.—Foreign bodies in the bronchi seriously endanger life. They usually lodge in the right bronchus. When a small lung-area is obstructed the obstructed side shows diminished respiratory movement and murmur with occasional whistling sounds and large moist râles; the percussion-note is normal. When an entire lobe is obstructed all respiratory sounds are absent over it, and over the unobstructed lung respiration is exaggerated; the percussion-note over the obstructed area is at first resonant, but becomes dull. The x-rays will enable the surgeon to detect some foreign bodies in a bronchus. Lodgment in a bronchus may cause bronchopneumonia, abscess, hemorrhage, and even gangrene. In some cases the body has been expelled spontaneously. In rare instances people have lived for years with lodged foreign bodies. If death does not soon follow the lodgment of a foreign body, an abscess is very apt to form.

Treatment.—If a foreign body lodges in the pharynx, try to pull it forward; if this fails, push it back into the esophagus. In lodgment in the larynx or below, if the symptoms are very urgent, at once perform a quick laryngotomy. If the symptoms are not so urgent, get a complete history of the accident and find out the nature of the foreign body. Be sure a foreign body is retained in the respiratory tract, and determine what its situation may be. Often a laryngologist can remove a foreign body from the larynx by means of forceps, a mirror and lamp being used for illumination. The fauces and upper portion of the larynx should have cocain applied to them to lessen pain and spasm. If the surgeon fails in extraction by forceps, and laryngotomy has been performed, continue the search through the opening in the cricothyroid membrane; if laryngotomy has not been performed, let the larynx be opened by *thyrotomy* (a vertical incision between the alæ of the thyroid cartilage, and the separation of these alæ to permit of exploration). After a thyrotomy suture the perichondrium with catgut. If the foreign body is in the trachea, perform ordinary tracheotomy; if it is in a bronchus, perform low tracheotomy. Tracheotomy prevents suffocation from laryngeal spasm or edema of the glottis. It may be possible to remove the body in the bronchus through the incision of a low tracheotomy, and this ought to be tried. The foreign body may be expelled through the tracheotomy wound; if it is not expelled, search

the trachea and bronchi with Gross's forceps, with probes, with hooks, or with the finger. If the foreign body cannot be found, put the patient to bed, and maintain a moist atmosphere in the room. As a rule, when the foreign body is not found insert a tube. If the foreign body be extracted, do not insert a tube (unless edema of the glottis exists or is likely to come on), do not suture the wound, but cover it with moist gauze and let it heal by granulation. Morphin and sedative cough-mixtures are given. Gross says that even when a foreign body has long been retained an operation should be performed if the air-passages are not seriously diseased. What shall be done when a foreign body is lodged in a bronchus and we are unable to extract it through a tracheotomy-wound? Truc said if "the patient is in danger of death" go through the chest-wall and attempt to remove the body. He said this with a full knowledge of the difficulty of locating the body. This difficulty has been partly overcome by the *x*-rays, and it seems now more certainly our duty to operate than it was a short time ago. Nasiloff proposed to reach the obstruction by the posterior route after rib resection. Curtis attempted this, and though the patient died, his operation proves that the method is feasible. An operation by the posterior route should be performed at once, if low tracheotomy fails.

Operations on the Larynx and Trachea.

Tracheotomy.—The instruments required in this operation are scalpels, dissecting forceps, a dry dissector, hemostatic forceps, scissors, a tenaculum, aneurysm-needle, tubes, tapes, Paquelin cautery, needles, needle-holder, a mouth-gag, tongue-forceps, foreign-body forceps, retractors, and, if membrane is present, feathers and a solution of bicarbonate of sodium. In a formal operation give chloroform, but in an emergency case this cannot be done. The patient may be placed supine with a sand-pillow under the neck and with the head thrown over the end of the table. If a child, Liston used to wrap it up to the neck in a sheet to prevent movements of the limbs, would seat himself on a chair, place the child upon the nurse's lap, and takes its head between his knees. The head must be exactly in the middle line, and extended (in an adult this gives two and three-quarters inches of trachea above the manubrium; in a child of ten, two and a quarter inches; in a child of six, about two inches). The operator stands to the right side when the patient is supine. If bleeding is profuse when the surgeon is ready to open the trachea, place the patient in the Trendelenburg position with the neck extended. The trachea may be opened above or below the isthmus of the thyroid gland. The isthmus in an adult usually lies over the second and third rings (Fig. 425). The isthmus in a child usually lies over the first ring or even over the space between the cricoid cartilage and the first ring. The high operation is always

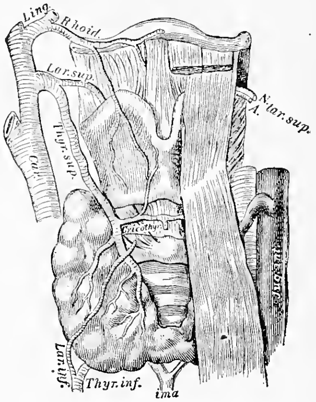


Fig. 424.—Blood-supply of the larynx and trachea (Esmarch and Kowalzig).

chosen except in cases where it is desired to search for a foreign body in a bronchus.

High Tracheotomy.—High tracheotomy is preferred because in this region the muscles are distinctly separated (Fig. 425), the main vessels of the neck and the inferior thyroid vessels are not encountered, the anterior jugular veins are small and have very few transverse branches, and the trachea is near the surface (Treves). The surgeon accurately locates the cricoid and thyroid cartilages. An incision is begun at the upper border of the cricoid cartilage, and is carried down precisely in the middle line for about one and a half inches. Treves advises the operator to steady the skin of the neck with the fingers of the left hand and to cut with the unsupported right hand (if the hand be supported, the respirations will interfere with the operation). The skin, the superficial fascia, and the anterior layer of the cervical fascia are incised, the sternohyoid and sternothyroid muscles are separated, and the fascia over the trachea is divided. This fascia is attached above to the cricoid cartilage, and it divides below into two layers to invest the thyroid body and its isthmus. If veins are in the line of the incision, they are pushed aside, but it is not necessary to take the time to apply double ligatures. Even if bleeding is profuse, as soon as the trachea is opened and air enters freely into the lungs, venous congestion is relieved and bleeding is apt to cease. If hemorrhage be violent and the veins are not at once caught by forceps, it may be well to place the patient in the Trendelenburg position before incising the windpipe, in order to prevent the entrance of blood into the lungs. Before opening the trachea the isthmus of the thyroid gland is pushed downward; if it cannot be pushed down sufficiently, a transverse incision is made through the fascia at the upper border of the cricoid cartilage, and the fascia, and the isthmus with it, is lifted off the trachea (Bose's method). A tenaculum is inserted into the cricoid cartilage in order to steady the tube. The back of the knife is turned toward the sternum, a finger being held upon the blade to prevent too deep a cut being made. The knife is plunged, as if it were a trocar, into the mid-line of the trachea above the isthmus, and two or three rings are divided from below upward. The hook is not removed until the operation is completed. If a foreign body is present, an attempt is made to remove it; if success attends the effort, no tube need be worn; but if the body is not found, a tube must be used. In croup or diphtheria remove membrane (by means of a feather and a solution composed of bicarbonate of sodium ℥ij, glycerin ℥j, water ℥x—Parker) and insert a tube. The edge of the cut is grasped with the dissecting forceps, the mucous membrane being included in the bite; the head is placed erect, the tube is introduced, and the tenaculum is removed. Secure the tube by tapes, and suture the wound below the tube. Remove the tube at the first moment consistent with safety. In croup or diphtheria put a screen around the bed; have the air kept moist by steam; remove the inner tube and clean it every two or three hours at first; clean the outer tube whenever required. Clean the larynx and trachea from time to time by means of a feather and Parker's solution. A steam spray atomizer may be used with advantage.

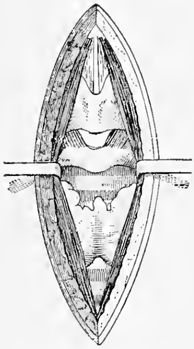


Fig. 425.—Parts exposed in tracheotomy (Esmarch and Kowalzig).

Quick laryngotomy must never be attempted upon a child under thirteen years of age, because of the small size of the cricothyroid space before this age (Treves). In view of the difficulty of introducing a tube and of wearing it so near the vocal cords, laryngotomy should not be performed for croup, diphtheria, or for any condition in which a tube must be long worn. The operation is performed as follows: Make an incision an inch and a quarter in length in the middle line, from above the lower edge of the thyroid to below the lower border of the cricoid cartilage. Divide the skin, superficial fascia, and deep fascia, separate the cricothyroid and sternothyroid muscles, divide the deep layer of fascia, and cut the cricothyroid membrane horizontally just above the cricoid cartilage. The tube must be shorter than the ordinary tracheotomy tube. An operation which opens vertically the cricothyroid membrane, the cricoid cartilage, and the upper rings of the trachea is called "*laryngo-tracheotomy.*"

Intubation of the larynx (*O'Dwyer's Operation*).—Bouchot conceived the idea of intubation; O'Dwyer perfected it and made it a genuine scientific proceeding. The instruments required for the performance of this operation are a mouth-gag, an instrument to hold the tube and introduce it, and an instrument for extracting the tube. The collar of the tube has a perforation through which a piece of silk is fastened to draw out the tube. The child is wrapped in a sheet to secure the limbs, is seated in a nurse's lap, and its head is held by an assistant. The jaws are opened and held apart by the self-retaining mouth-gag. The surgeon sits in front of the patient, wraps a piece of rubber plaster about the index-finger of his left hand, and passes the finger into the child's mouth until its tip touches the epiglottis. He introduces the holder and tube (observing if the silk is free) along the surface of the tongue until the obturator touches the epiglottis; raises the epiglottis with the left index-finger, and passes the tube into the larynx; places the left index-finger against the tube, and withdraws the holder with the right hand. The silken thread is tied to the ear, and the nurse is directed to employ the thread to remove the obturator if it becomes obstructed or is coughed up. The tube is removed in two or three days; if breathing is easy, it is not reintroduced; but if dyspnea recurs, it is replaced for two or three days more. If, in introducing the tube, a mass of false membrane is pushed before it into the trachea, breathing ceases, and, if the mass is not at once coughed up, tracheotomy must be performed. Feed these patients on semisolids rather than upon liquids (mush, soft eggs, and corn-starch); and if trouble occurs in swallowing these articles, feed by the rectum or by means of a nasal or an oral tube. In opium-poisoning, in asphxyia, in acute traumatic pneumothorax, and in cerebral injuries, intubation may be associated with the use of Fell's apparatus (page 777).

Diseases and Injuries of the Chest, Pleura, and Lungs.

Traumatic Asphyxia (*Pressure Stasis; The Ecchymotic Mask*).—This is a condition that occasionally arises when the trunk is subjected to sudden and violent compression. The compression may be upon the chest, the abdomen, or both; and in the majority of cases it has been very temporary. The ecchymotic condition arises immediately, and is manifested over the head and neck down to and sometimes below the clavicle. The hue is a

violet lividity. There are a great many spots in the skin in which the color is much deeper, which have been supposed to be hemorrhage, and similar spots exist on the aural, palatine, and pharyngeal mucous membranes. In some cases blood has been effused into the orbit. There has never been any reported instance of intracerebral hemorrhage.

If death occurs, it results from associated injuries. The condition in the cases without severe associated injuries has soon disappeared, and entire recovery has followed. The view generally taught is that traumatic asphyxia is the result of compression of the abdominal veins, causing distention of the superior cava and its tributary veins, this region of the body showing the effect more than the limbs, because of the comparative feebleness of the valves (Villemin). One thing is sure, and that is that the condition is particularly apt to arise if the patient violently struggles to free himself from the compression; and many observers have held the opinion that actual vascular ruptures take place. There are certainly some cases, however, in which there is simply great venous and capillary distention in the skin without rupture, because pieces of skin have been excised and microscopic examination has indicated that there had been no blood effused. (See Winslow, "Medical News," Feb. 4, 1906; Birge, "Cleveland Medical Journal," Sept., 1905; Beach and Cobb in "Annals of Surgery," April, 1904; and Villemin, "Bull. et mém. de la Soc. Chir. de Paris," No. 9, 1906.)

Pleuritic effusion may arise from the lodgment of foreign bodies, from injury by fragments of a broken rib, from tumors, and from inflammation of the lung, but most usually is due to pleuritis. The commonest cause of primary pleuritis is tuberculosis. Inflammatory effusion is nearly always unilateral (except in tuberculous pleuritis, but even this form is often one-sided in origin).

The **signs** of pleuritic effusion are: dulness on percussion over the area of effusion, this dulness, when the patient is erect, being at the lower part of the chest and ascending higher posteriorly than anteriorly (alteration of position alters the situation of the dulness); the intercostal spaces are widened, the intercostal depressions are obliterated, the intercostal muscles are rigid, and their rigidity lessens the mobility of the ribs (Przewalski). No breath-sounds can be detected in the area of percussion flatness when the collection of fluid is large, but in small effusions deeply situated the breath-sounds are often audible; the percussion-note above the liquid is hyperresonant or tympanitic, and is often associated, at the edge of the liquid, with a friction-sound; posteriorly, high up and near the spine, there are bronchial respiration and bronchophony. In cases of pleurisy with effusion pain almost or quite disappears with the advent of effusion, dyspnea comes on, and the patient lies upon the diseased side. Cough always exists if there is pleuritic effusion, and fever is usually present. In serous effusions the diagnosis may be confirmed by the aseptic introduction of a clean aspirating-needle.

The **treatment** in this stage is to discontinue arterial sedatives and to stimulate if the circulation calls for it. The exudation is removed by the administration of salines, compound jalap powder, or elaterium. If these means fail, if the effusion is excessive, or if it is producing dyspnea, at once aspirate. Aspiration should be performed for an effusion which fills the whole chest, which produces great dyspnea, or which has lasted for three weeks. In tuberculous pleuritis early aspiration is not advisable, but aspiration should be

performed if the fluid becomes purulent, if the effusion displaces the heart considerably, and if it adds notably to the dyspnea. If an effusion becomes purulent, the proper procedure is incision, resection of a portion of a rib, and drainage.

Empyema is a collection of pus in the pleural cavity. It may begin suddenly, but rarely does so. Among the causes of empyema are those of serous effusion. Empyema is due to infection of the pleura, and in every case a bacteriological study should be made of the pus to discover the causative bacterium. The pneumococcus is the causative micro-organism in many of the cases which follow pneumonia. Pneumococci live but a short time, and in empyema due to pneumococci these micro-organisms may not be discoverable when the pus is evacuated. In most cases of empyema streptococci or staphylococci can be found in the pus. These micro-organisms may appear in an empyema induced originally by pneumococci (Stephen Paget). In empyema developing during or after typhoid fever typhoid bacilli may be discovered. In putrid empyema various bacteria are found. Bouchard thinks acute empyema has a special organism. Bacilli of tuberculosis are present for a time at least in tuberculous empyema, but may disappear, and are particularly apt to after mixed infection with pyogenic bacteria. Empyema may be due to a wound or contusion, an attack of pneumonia, tuberculous pleuritis, phthisis, influenza, pyogenic infection of a serous effusion, caries of a rib, specific fevers, especially typhoid, peritonitis, abscess of the liver, suppurating hydatid cyst of the liver, subphrenic abscess, malignant disease of the pleura, gangrene of the lung, and pneumothorax.

Acute Empyema.—The *signs* are in reality those of pleuritis with effusion—viz., dulness on percussion, absent breath-sounds over the purulent matter, bulging of the intercostal spaces, and sometimes edema of the skin of the chest. The *symptoms* of acute empyema are dyspnea, pallor, cough, sweats, chills, and usually irregular fever, but fever may be absent. There is marked leukocytosis. The fingers may become clubbed. An empyema may pulsate, particularly an empyema of the left side. The cause of *pulsating empyema* has been much debated. The most probable explanation is that of W. J. Calvert ("Am. Jour. Med. Sciences," Nov., 1905). He says the requirements for such a condition are: "A firmly fixed, pulsating organ; distention of the pleural sac with fluid or air or solid material; and a collapsed condition of the lung." In all probability the thoracic aorta is the "fixed pulsating organ." The left parietal pleura is in close relation with the aorta, and most pulsating empyemas are left-sided. The right parietal pleural may be "pushed against the aorta." If a lung contains air, it is elastic and compressible to a degree that enables it to absorb the aortic impulse; if it is collapsed and solid it cannot, and aortic pulsations are transmitted to fluid in the pleural cavity and the thoracic wall pulsates. A neglected empyema may break into the lung, esophagus, or pericardium, through an intercostal space, or may point in the lumbar region. When an empyema is pointing externally, the condition is called *empyema necessitatus*. A *total empyema* is a condition involving the entire pleural sac. In a *partial* or *localized empyema* the purulent matter is encapsuled. After an empyema ruptures spontaneously it rarely heals without surgical interference, a *pleural fistula*, as a rule, persisting. A *subphrenic abscess* may

follow an empyema. When an empyema ruptures into a bronchus, pneumothorax arises, as a rule. Empyema may cause death by compression of the heart and lung, pulmonary embolism, pericarditis, peritonitis, cerebral embolism, cerebral abscess, septicemia, exhaustion, or rupture into a bronchus.

A small empyema due to pneumococci occasionally, though very rarely, undergoes spontaneous cure, the pus being absorbed (Stephen Paget).

A small empyema is occasionally cured by encapsulation with fibrous tissue.

Under exceptional circumstances even a large empyema may be cured by breaking externally or into a bronchus.

Empyema is so rarely cured spontaneously that it does not do to trust to nature, and practically almost every case will die without surgical treatment.

Double empyema is a rare and extremely fatal condition.

Chronic empyema may follow an acute empyema, or the condition may be chronic from the beginning. In chronic empyema the lung is compressed, shrunken, and strongly adherent, and the pleura is very thick. In some cases the pleura is over an inch thick. This thickening is brought about by the deposition of layer after layer of fibrin. In not a few cases a chronic empyema succeeds an acute one or is itself maintained because a drainage-tube has slipped into the pleural cavity and remains lodged.

A *closed empyema* is one in which no opening has been made by the surgeon and no opening has formed spontaneously. In a closed empyema the pus is rarely putrid; in an *open empyema* the pus is often putrid.

Treatment of Empyema.—The treatment is purely surgical, and the earlier it is applied the better. To delay allows the pleura to thicken and permits adhesions to form, conditions which prevent lung expansion and retard or even prevent cure. The results of operation are better in children than in adults; in small collections than in large; in recent than in advanced cases; in pneumococcus empyema than in empyema due to other organisms. The surgical methods comprise aspiration, incision, rib-resection, the operation of Schede, the operation of Estlander, and the operation of Fowler (see pages 783 to 787 inclusive).

In acute empyema general practitioners are very apt to *aspirate*, and yet aspiration is almost never curative. It may cure a pneumococcus empyema in a child and an encysted empyema, but even in these it will usually fail. Aspiration is not to be considered a method of curative treatment. It is to be regarded as the surgical treatment only in a tuberculous empyema in a young person with rapidly progressing phthisis, because in such a case incision will probably prove fatal (Lockwood). It is a very useful diagnostic expedient, and enables the surgeon to prove the existence of pus, and the pus which is obtained can be examined bacteriologically. In a very large effusion it is wise to aspirate and withdraw part of the effusion a day or two before operating. This enables the patient to take an anesthetic with greater safety and obviates the danger attending the rapid evacuation of a large amount of pus.

In a recent empyema *incision and drainage* or rib resection and drainage will often cure the case, and yet many of the results are unsatisfactory. In some cases the discharge ceases and yet pulmonary function is not completely restored. In other cases a pleural fistula persists. If a profuse discharge is maintained, amyloid disease may arise. An acute empyema is to be drained by intercostal incision or by resection of a rib (page 784). A chronic closed

empyema is drained in the same manner, and if the lung will not fully expand and remains stationary for one year Schede's or Estlander's operation is required. An open chronic empyema, in which the lung will not expand, requires the operation of Schede, Estlander, or Fowler (pages 786 and 787). Extensive decortication is sometimes impossible, and then Ransohoff's operation may be done. He calls it *discission of the pulmonary pleura* (page 787). When there is an external opening which persists and which joins a long, narrow cavity, the condition is spoken of as *pleural fistula*, and pleural fistula is often produced by the prolonged use of a drainage-tube and sometimes by caries of a rib. A pleural fistula may sometimes be cured by dilatation of the sinus, but in most cases it is necessary to resect one or more ribs. Even if there is no opening on the cutaneous surface, there may be one into a bronchus.

Non-traumatic Pneumothorax.—By the term pneumothorax is meant the presence of air in the pleural cavity. As a rule, besides air there is serous fluid or pus. It may be due to the rupture of an empyema into a bronchus; to the rupture into the pleural sac of a tuberculous area, an area of gangrene, an abscess of the lung, an air-cell in a state of emphysema, or of pulmonary tissue softened because of hemorrhagic infarction. The immediate effect of the entrance of air into the pleural sac is to compress the lung, the degree of compression being in proportion to the amount of air present. In severe cases the lung is squeezed against the vertebral column, and the heart, the diaphragm, and even the liver are displaced. In some cases, where the admission of air does not continue, the amount set free in the pleural sac is absorbed. In most cases pyopneumothorax (empyema) follows.

Symptoms.—The symptoms usually arise suddenly, and consist of distressing dyspnea, pain in the chest, lividity, and rapidity and weakness of the pulse. In some cases of phthisis the symptoms are not very severe. It has been pointed out that occasionally in phthisis pneumothorax seems actually to benefit the tuberculous area in the lung. The physical signs of pneumothorax are as follows: The affected side of the chest is bulged and immobile, and the heart is displaced, especially if the condition affects the left side. Palpation discovers that vocal fremitus is lessened or absent. On auscultation it is found that the breath-sounds are very feeble or absent. The voice is transmitted as a metallic sound, the râles sound metallic, and on coughing there may be metallic tinkling. The percussion-note is tympanitic. In some rare cases the percussion-note is dull. When fluid gathers, there is a positively dull note on percussion over the fluid.

Treatment.—Osler says the treatment should be the same as that of pleurisy with effusion. In many cases it is wise to perform paracentesis without suction to remove air and serous effusion. If pus forms, a rib should be resected and a tube inserted (see Empyema). In pneumothorax occurring during chronic phthisis operation is of great service. In cases with rapidly progressive phthisis it is practically useless.

If the opening into a bronchus or air-cell remains patent, aspiration will not get rid of air; the air will enter into the pleura as rapidly as the aspirator removes it. Incision has dangers of its own: the diaphragm is flapping during respiration and may be injured (Fowler), and when the pleura is opened, there is a great alteration produced in the air-pressure in the chest, and the

patient may "drown in his own secretions." After incision irrigation is not justifiable, because the fluid may enter a bronchus and produce suffocation (Fowler).

West's rules are the ones I follow *—West says early incision is dangerous. In an early stage use paracentesis without suction. This will often relieve the patient. If paracentesis does relieve him, wait a while and perhaps repeat the operation if the symptoms again become severe. If paracentesis does not relieve, incise, resect a portion of a rib, and drain. If pus forms, an incision must be made and a portion of a rib resected, to afford exit to the fluid.

Fowler points out that if the lung is bound down by adhesions, incision is dangerous but justifiable. Operation at the proper time often prevents the lung being bound down by adhesions.

Acute Traumatic Pneumothorax.—This is produced by the sudden admission of a quantity of air into the pleural cavity as a result of a wound of the chest-wall. A small quantity of air, or the gradual introduction of considerable air, does not, as a rule, produce very serious symptoms. The sudden admission of a quantity of air causes very dangerous symptoms, and even death. A quantity of air may be admitted rather suddenly as a result of an accident or during the performance of a surgical operation which opens the pleura. It sometimes arises during the removal of tumors from the chest-wall, during operations upon the lung, and during empyema operations. As a rule, when pulmonary adhesions exist, dangerous symptoms do not arise, even when the pleura is widely opened, and adhesions exist in 25 per cent. of empyema cases seen by the surgeon.†

It was formerly taught whenever the pleura is opened there is a strong tendency to the development of pneumothorax, but West has shown that the surfaces of the pleura often cohere with a force superior to pulmonary elasticity, and in such cases pneumothorax does not arise.

In surgical operations in which it is necessary to open the pleura widely (as in operation for sarcoma of the chest-wall) the surgeon endeavors to prevent acute pneumothorax which may prove fatal. This may be done by operating in the Sauerbruch chamber, which exposes the patient's thorax to negative pressure, but which permits the head to lie out of the chamber so that the bronchioles will be subjected to ordinary atmospheric pressure. The lungs are distended because of the lessened pressure of the external air. It may be done, and usually is, by pumping air into the lungs through a trachea tube or through an intubation tube (see the Fell-O'Dwyer apparatus, page 777). Brauer advocates the following plan. After the patient has been anesthetized and when the surgeon is just ready to open the pleura, a glass case is placed over the patient's face and the air is condensed by means of an apparatus.

Symptoms.—When the pleura is opened during an operation or by an injury, the symptoms may be trivial and transitory, may be tolerably severe, may be extremely grave, and the patient may quickly die (Quénu and Longuet). Rudolph Matas sets forth the symptoms as presented by the French observers:‡

The mild symptoms are a weak, slow pulse and irregular, noisy respiration.

The severe symptoms are slow pulse, slow and irregular respiration, and dyspnea, continuing after the anesthetic has been withdrawn.

* Brit. Med. Jour., Nov. 27, 1897. † Rudolph Matas, Annals of Surgery, April, 1899.
‡ Annals of Surgery, April, 1899.

The grave symptoms are cyanosis; collapse; small, weak pulse; shallow and noisy respiration; and spells of syncope. Death may occur suddenly from inhibition, or later from mechanical asphyxia (Matas).

Treatment.—Various plans have been adopted: suturing the opening in the pleura; plugging the opening; pulling the diaphragm into the wound in the chest-wall and suturing it; and grasping the lung and suturing it to the wound. Whenever the pleura is widely opened, follow the advice of Matas and use the Fell-O'Dwyer apparatus, and when the operation is completed, suture the lung to the margin of the opening in the pleura with a continuous catgut suture. Parham, Keen, and the author have followed this plan and the lung was kept from collapsing.*

The Fell-O'Dwyer apparatus is shown in Fig. 426.

O'Dwyer's tube is introduced into the glottis as is the tube in intubation, and is attached to a bellows, the lung is inflated, respiration is maintained by the use of the bellows, and collapse with all its dangers is avoided.

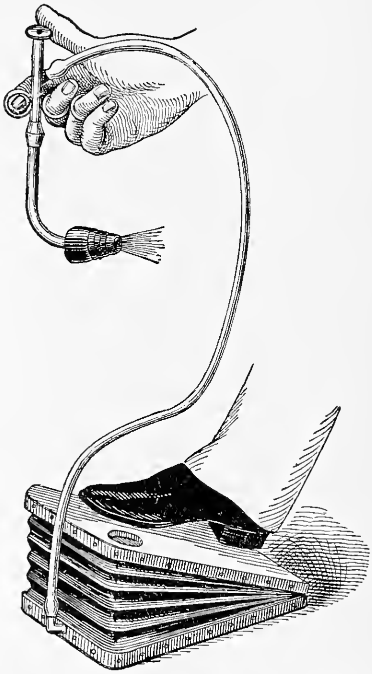


Fig. 426.—The Fell-O'Dwyer apparatus. This illustration shows an early model; since then the bellows has been improved by the addition of a strong wooden frame, which holds it steadily, and is provided with a long arm that acts as a powerful foot-piece for compressing the machine with the least amount of muscular effort.

Contusions and Wounds of the Chest.

Contusions.—A contusion may be trivial and limited to the superficial parts of the chest-wall; it may involve the muscles; it may be associated with fracture of the ribs or sternum or with visceral injury.

Symptoms.—In an ordinary contusion without visceral injury there are considerable pain, discoloration, and often much swelling. The patient prefers to lie upon the back and the respiration is abdominal. After a severe blow upon the chest there is great shock and may even be instant death. The condition of shock so produced is called concussion of the chest. Broken ribs may injure the pleura or lung. After a severe blow upon the chest a limited area of inflammation may arise in the pleura (*traumatic pleuritis*). Severe visceral injury is announced by positive symptoms. A *contusion of the lung* causes pain, cough, expectoration of bloody mucus, dyspnea, and possibly distinct hemoptysis. Over the contused region the percussion-note is dull and on auscultation crepitus is audible. A *limited pneumonia* always follows, but genuine croupous pneumonia may arise.

In **rupture of the lung,** besides the symptoms above noted, there are hemothorax and pneumothorax.

* F. W. Parham's paper on "Thoracic Resection for Tumors Growing from the Bony Walls of the Chest." Read before the Southern Surgical and Gynecological Association, November, 1898.

Rupture of the diaphragm causes pain and dyspnea and often vomiting. The stomach or intestine may pass into the pleural sac. If this happens, there will be a tympanitic percussion-note over the displaced viscus and symptoms will vary with the viscus involved. In a case in the Jefferson Medical College Hospital, in which the stomach passed into the left pleural sac, there were persistent vomiting, violent pain in the chest and upper abdomen, great thirst, and displacement of the apex-beat. Such a diaphragmatic hernia may become strangulated. (See page 993.)

Treatment of Contusions of the Chest.—A contusion of the chest-wall is treated as directed in the section on Contusions (page 237), and the chest is strapped with adhesive plaster, as in the treatment of fractured ribs. In concussion of the chest the treatment for shock is applied. It may be necessary to employ artificial respiration for a time. If a diaphragmatic hernia is diagnosticated, the abdomen should be opened, the displaced viscera restored to their proper abode, and the diaphragm sutured. The diaphragm may also be reached by resecting several ribs and opening the pleural sac. In contusion of the lung cold is applied to the chest, and any inflammation which arises is treated according to general rules. In rupture of the lung the case may be treated expectantly, but dangerous and continued bleeding or pneumothorax may render surgical interference necessary.

Wounds of the Chest.—Non-penetrating wounds are not particularly grave, and are treated according to general principles, the chest being immobilized. Penetrating wounds are extremely grave, as viscera are apt to be injured. In such a wound an intercostal artery may be severed or the internal mammary artery may be divided. An intercostal artery is rarely divided unless a rib is broken. The surgeon should always examine carefully in order to determine whether an intercostal artery or the internal mammary artery has been divided, and, in doing so, should bear in mind the admonition of Matas—that is, the bleeding from these vessels may be internal, the blood collecting in the pleural sac. The pericardium or heart may be injured (page 344). A wound of the pleura is usually, but not always, associated with a wound of the lung. If the lung is injured, there are usually great shock, pain in the chest, dyspnea, and cough. In a large wound, damage to the lung will be indicated if air is sucked into the wound during inspiration and expelled during expiration, and blood is forced out of the wound by coughing. The lung may be visible or may protrude (*protrusion of the lung*). In a small wound it is often difficult and sometimes impossible to determine whether the lung has been injured. Pneumothorax with pulmonary collapse proves it has. Severe hemothorax strongly suggests it. Spitting blood does not prove it. In some severe cases there is no hemoptysis; in some slight bruises the amount of blood coughed up is large. Emphysema about the wound does not prove lung injury. An incised wound of the lung is apt to produce rapid death from hemorrhage, especially if the wound is at the root of the lung. A pistol-bullet or a sporting-rifle bullet is not usually productive of great primary hemorrhage; but infection probably follows, and secondary hemorrhage is apt to occur. The modern military-rifle ball passes through, rarely lodges, is aseptic, and often produces astonishingly little trouble. A pistol-bullet and an old-time rifle bullet may lodge or may perforate.

Treatment.—Bring about reaction as previously directed (page 242).

An incised wound of the chest, if large, should be carefully inspected. If the wound is small, cut down layer by layer until the depths of the wound are reached. Disinfect the wound and arrest hemorrhage. If the pleura is not open, proceed according to general rules. If the pleura is found to have been opened, suture it with catgut, close the superficial wound, dress with gauze, and immobilize the chest-wall.

The above proceeding should be carried out whether it is or is not believed that the lung has been damaged, provided there is no pneumothorax and no violent hemorrhage. What course shall be pursued if the lung has been injured by a stab? If hemorrhage does not threaten life and there is no pneumothorax, the patient is kept at rest and observed. If pneumothorax occurs, the pleural sac must be drained by means of a tube, because clots must be evacuated and infection should be anticipated. If hemorrhage into the pleural sac persists, active measures become necessary. The use of ice-bags and drugs is but waste of time. Some surgeons believe that the mere closure of the external wound leads to arrest of hemorrhage, blood accumulating and making pressure. It is true that hemorrhage often ceases after suturing or plugging a wound and strapping the chest, but it is not probable that it ceases because of these measures. Blood in the pleura usually remains unclotted for several or many days. Further, as Le Conte shows, as the blood is forced against the root of the lung, the right heart is engorged, the blood-pressure is raised, and the bleeding continues.*

Bleeding from the lung can often be arrested by inserting the end of a drainage-tube into the pleural sac. In cases where a drainage-tube is inserted into the pleural cavity and free drainage established, the pleura is immediately filled with air, and the muscles of respiration are kept from acting on the lung. The lung contracts by its own elastic tissue, as well as by the pressure exerted by the pneumothorax, and at the same time the presence of the air favors clotting in the severed vessels.† If the insertion of a tube fails, or if the bleeding is rapid and obviously seriously threatens life, several ribs must be rapidly resected and the bleeding part explored. In some cases the bleeding may be arrested by ligation, in some cases by packing a small wound with gauze, in some cases by the suture ligature. In a violent secondary hemorrhage following a gunshot-wound of the lung the author packed the entire pleural cavity with sterile gauze to obtain a base of support, and arrested the bleeding by carrying iodoform gauze directly against the oozing surface.‡ After directly arresting hemorrhage from the lung, turn clots out of the pleural sac and insert a drainage-tube. In a perforating wound inflicted by a bullet reaction must be brought about, the wound dressed antiseptically, the chest strapped, and the patient kept quiet. If pneumothorax occurs, the pleura should be drained with a tube. If hemorrhage occurs, it should be met as directed above. In a wound in which the bullet has lodged an examination should be made to see if the bullet is under the skin, and if it is, it is removed after the patient has reacted. It should always be borne in mind that a pistol-bullet may be deflected by a rib or may pass from the front to the back part of the chest by making a burrow under the skin (*a contour wound*). If a bullet is lodged, no attempt should be made to remove it unless an opera-

* Annals of Surgery, April, 1899.

† Le Conte, in Annals of Surgery, April, 1899.

‡ Annals of Surgery, Jan., 1898.

tion must be done for bleeding, unless the bullet causes trouble, or unless it is felt under the skin. Under no circumstances conduct a long search for a bullet. If emphysema of the chest-walls is moderate, strapping or a bandage will control it; if it is great, make multiple punctures and then apply pressure. In protrusion of a portion of the lung try to restore the protrusion; but if restoration is impossible or if gangrene seems likely to occur, ligate the base of the protrusion with silk and cut away the mass.

Abscess of the lung may follow ordinary pneumonia. It is apt to follow aspiration-pneumonia. It is usually caused by streptococci or staphylococci, but it may result from pneumococci or colon bacilli. These germs may reach the pulmonary tissue by direct entrance from adjacent organs, by way of the blood or by way of the bronchi and alveoli. Osler tells us that pulmonary abscess may result from the aspiration of septic particles after "wounds of the neck, operations upon the throat," and suppurative lesions of the nose, larynx, or ear.* Aspiration-pneumonia may develop when there is difficulty in swallowing from any cause, when there is profound exhaustion, and when there is palsy or incoördination of any of the muscles of deglutition. Cancer of the esophagus may be a cause; so may perforation of the lung by an abscess, wound of the lung, impaction of a foreign body in the lung, suppuration about a focus of tubercle or a metastatic abscess. A pulmonary abscess may be of trivial size or it may be very large, involving an entire lobe. There may be one abscess, several, or many. When suppuration results from aspiration-pneumonia or blood-infection, there are usually multiple abscesses.

Symptoms.—The expectoration is not frequent, but is profuse, and during a paroxysm mouthfuls are coughed up in rapid succession. The expectorated matter is sour or very offensive in odor and contains fragments or shreds of pulmonary tissue, which can be identified as such by the microscope. The patient lies upon the diseased side in order to keep the pus from running into the bronchi and causing cough. When the cavity fills and pus reaches the bronchi, violent cough and expectoration begin, continue until the cavity is partly or entirely emptied, and then subside, perhaps for several hours. If the abscess-cavity is large and full of pus, an area of dulness on percussion can be mapped out. When the pus is coughed out and the air enters, physical signs of a cavity are clear. The *x*-rays often show the situation of such a cavity.

The course of abscess of the lung is usually acute. There are fever of the hectic type, rapid loss of weight, weakness and rapidity of circulation, dyspnea, pallor, sleeplessness, and great weakness. Gangrene may arise; empyema or pyopneumothorax may develop; very rarely the abscess breaks through the chest-wall; recovery may follow spontaneous evacuation or drainage by coughing up pus; death may result from exhaustion or secondary septic lesions. If operation is performed, from 50 to 60 per cent. of the patients will recover.

The **treatment** is purely surgical (*pneumotomy*). Make an incision over the cavity. Resect a portion of one or more ribs. Expose the pleura. If the two layers of the pleura are not adherent, suture them together and wait two days. If they are adherent, proceed at once. Search for the abscess

* See Osler's "Practice of Medicine."

with an aspirating needle. When the cavity is found, open into it with the cautery and insert a drainage-tube (page 787).

Gangrene of the Lung.—This term means the putrefaction of a devitalized portion of pulmonary tissue. The tissue is devitalized by the action of pyogenic micro-organisms. Gangrene may follow abscess, bronchitis, or pneumonia, or may be due to diabetes, to embolism of the pulmonary artery, bronchiectasis, tuberculosis, malignant disease, wounds, or the lodgment of foreign bodies. Gangrene may be circumscribed or diffused. There may be one cavity, small or large, or multiple cavities may form. The gangrenous area putrefies, softens, and the softened matter may be expectorated, a gangrenous cavity being formed. In the rare cases which undergo spontaneous cure the cavity is, after a time, surrounded by fibrous tissue and obliterated by granulations.

Symptoms.—Expectoration occurs only now and then, but at each seizure a great quantity of matter is brought up and this matter is extremely offensive. Occasionally there is no expectoration. The patient, as in lung abscess, lies upon the diseased side. The expectorated matter is mucopurulent, contains particles or shreds of pulmonary tissue, bacteria, and altered blood. The fetor of the pus is much greater than is the fetor of the pus of an abscess. The breath is very foul. Physical signs may indicate either consolidation or a cavity. There are hectic fever, great exhaustion, deathly pallor, and diarrhea. Pulmonary hemorrhage is not unusual, and complications spoken of in the article upon Abscess may occur (page 780). Recovery sometimes ensues, the cavity closing by granulation. Death may take place in a few days. Often the patient lives for weeks, being sometimes better and sometimes worse, dying finally from exhaustion or from the effects of a complication.

The **treatment** is to operate as for pulmonary abscess.

Tuberculous Cavity in the Lung.—Surgical Treatment.—For the past decade surgical thought has been actively directed toward placing on a scientific footing operations for pulmonary phthisis. The matter is still in a transition stage, and operations at present have but a very limited field of application, although Sonnenberg and others have reported cures. Baglivi, in the seventeenth century, endeavored to tap and inject tuberculous cavities. Hastings and Stuckè did the same thing in the eighteenth century. Mosler, a number of years ago, attempted to treat cavities by introducing a trocar into the cavity and injecting permanganate of potassium solution through the cannula. Patients were not benefited by this procedure. The plan was revived by Pepper in 1874. The results are bad and the operation is dangerous. Hillier tried injection of corrosive sublimate into the lung-parenchyma, but the effect of the injections was disastrous. Vidal advocates counter-irritation by the actual cautery and maintains that congestion improves nutrition. When the strength of the patient is well preserved and the pulmonary lesion is circumscribed and slowly progressive, it may be justifiable to perform an operation, open the cavity, and treat it directly (*pneumotomy*). That pneumotomy might be performed successfully was suggested to surgeons by observing patients recover after sword-thrusts into the lung. Baglivi incised the lung in 1643. Fowler says it is not justifiable to operate if the disease has come "to a standstill." The same surgeon states that the only accessible region is bounded above by the clavicle, to the inner side by the manu-

brium, to the outer side by the lesser pectoral muscle, and below by the second rib.* This operation does not cure any one, but it may cause distinct improvement when there is hectic from an ill-drained cavity containing the products of a mixed infection. In an advanced case there is usually more than one cavity, and then the operation is contraindicated. Before attempting it, be sure the case is advanced and not incipient and that the cavity is single. Locate the cavity by auscultation, percussion, and the x-rays. (See Willard, "Jour. Amer. Med. Assoc.," Sept. 20, 1902.)

Mauclaise says that pneumotomy is justifiable only in circumscribed tuberculous cavities without peripheral infiltration and in pulmonary abscesses.† Bronchiectatic cavities are usually multiple; they are exceedingly difficult to locate, and treatment by pneumotomy should not be attempted. In the treatment of pulmonary tuberculosis resection of the diseased area has been proposed (*pneumectomy*). Tuffier successfully performed this operation. Surgeons, as a rule, do not believe in pneumectomy. Reclus voices the general opinion when he says the operation is not required if the area of disease is very limited, as such a condition is frequently curable by medicinal means, and it does no good if the area of disease is extensive.‡

It has long been known that pneumothorax might benefit a tuberculous lung. Attempts have been made by Farlanini and Murphy to cure phthisis by the deliberate production of *artificial pneumothorax*. Murphy injects nitrogen gas into the pleural sac, and believes that the method is of great value. It is maintained that Murphy's operation occludes the lymph-channels, prevents bleeding, compresses the lung, favors the development of fibrous tissue, and leads to healing of cavities. Every third or fourth week 120 c.c. of nitrogen gas are injected into the pleural sac. (See Willard in "Jour. Amer. Med. Assoc.," Sept. 20, 1902; Murphy's paper before Amer. Med. Assoc. in 1898; Lemke in "Jour. Amer. Med Assoc.," Oct. 14, 21, 28, 1899.)

Allis suggested that in extensive unilateral tuberculosis of the lung resection of a number of ribs will favor cure by permitting retraction of the chest-wall.§

Operations on Pleura and Lungs.

Exploratory Puncture of the Pleural Sac.—Puncture often gives valuable information as to the existence of fluid in the pleural sac and as to the nature of the fluid. The operation must be performed with aseptic care, otherwise a serous effusion might be converted into a purulent effusion, and either a serous or a purulent effusion might be rendered putrid. A large hypodermatic syringe with a long and strong needle is used for exploratory puncture. A slender needle breaks easily and is unsafe. In order to prevent breaking of the needle impress upon the patient the absolute necessity of keeping quiet and avoiding any violent respiratory or general movement during the operation. It is not desirable to stick the lung, although harm rarely results from such an accident. If no fluid is found in the pleura on one trial, several other punctures should be made. What is known as a dry tap may be due to the entire absence of fluid, to encapsulation of fluid

* See the very full and thoughtful article by George Ryerson Fowler on "The Surgery of Intrathoracic Tuberculosis," Annals of Surgery, Nov., 1896.

† La Tribune médicale, Sept. 21, 1893. ‡ Revue de Chirurgie, Nov. 11, 1895.

§ Allis, to State Med. Soc. of Penna. in 1891.

in a region not invaded by the needle, to the lodgment of the point of the needle in thickened pleura or in an adhesion, or to blocking of the lumen of the needle with coagula. Fowler points out that if a person has been recumbent for a long time, the upper layer of fluid may be clear while the lower layer is purulent.* The fluid should be collected in a sterile glass tube and subjected to a careful bacteriological study.

Paracentesis Thoracis.—The operation of tapping with a simple trocar and allowing the fluid to flow out through the cannula is no longer practised except in an emergency, when an aspirator cannot be obtained, or in an early stage of non-traumatic pneumothorax. An aspirator is a much better instrument.

Aspiration.—Aspiration consists in the introduction into the pleural sac of the tip of a hollow needle, the other end of which is attached by means of a rubber tube to a bottle from which the air has been exhausted. The fluid does not run out, but is sucked out, air is excluded, and bacteria do not enter the pleural sac. Fig. 333 shows a pneumatic aspirator. No anesthetic is required. The patient's skin, the instruments, and the surgeon's hands must be thoroughly asepticized. The patient is given a little whisky, and, unless he is very weak, he assumes a semi-erect attitude, with the arm hanging by the side. The trocar is introduced in the fifth interspace, just in front of the angle of the scapula. The surgeon marks the upper border of the sixth rib with the index-finger, and plunges in the trocar just above the finger, thus avoiding the intercostal artery, which lies along the lower border of the rib above. He guards the needle with the index-finger to prevent its going in too far. The fluid is withdrawn rather slowly in order that the patient may escape syncope and violent cough. If the patient becomes very faint, the operation should be abandoned. All the fluid present should not be removed at one sitting—complete removal of a large effusion is not safe. The operation can be repeated if necessary. After withdrawing the cannula place iodoform collodion over the opening in the chest. In an early stage of non-traumatic pneumothorax perform paracentesis without suction. In non-purulent pleuritic effusion, if the lungs will not expand after tappings, perform thoracotomy. In some cases aspiration is followed by pulmonary embolism or embolism at a distance. Syncope is a not unusual result. Convulsions occasionally occur. In rare cases the sudden withdrawal of a large effusion is followed by *albuminous expectoration*, as was pointed out by Pinault in 1853. It usually begins from a few minutes to half an hour after aspiration. When this complication arises, the pulse is very weak, there are severe dyspnea, cyanosis, cough, and the expectoration of quantities of a yellow, frothy fluid. Riesman ("Amer. Jour. of Med. Sciences," April, 1902) demonstrates that the condition is due to pulmonary edema and not to puncture of the lung. The sudden withdrawal of fluid by aspiration relieves the pressure which was compressing the lung, the lung becomes congested with blood (*congestion by recoil*, Riesman calls it), the blood distends weakened vessels, and profuse transudation takes place into the aircells. Most cases recover in a few hours or a day or two. Severe cases die from asphyxia. Terrilon collected 23 cases with 2 deaths. If albuminous expectoration arises, dry cup the chest and counterirritate with

* Annals of Surgery, November 1896.

mustard plasters. Perform venesection. Give oxygen by inhalation. Administer atropin hypodermatically. Employ artificial respiration if necessary.

Thoracotomy is an incision into the cavity of the pleura. It may be merely an intercostal incision, or may be an opening into the chest after resecting a portion of a rib. Often in a child with empyema good drainage can be obtained by an intercostal incision, but in most children and in all adults a rib should be resected. The instruments required for rib resection and thoracotomy are a scalpel, a grooved director, forceps (hemostatic and dissecting), scissors, a periosteum elevator, retractors, a costotome or metacarpal saw, rongeur forceps, drainage-tubes, and needles.

If there is very little dyspnea, ether can be given. If there is considerable dyspnea, chloroform should be given. If there is severe dyspnea, no general anesthetic is admissible. In severe dyspnea the patient is using certain voluntary muscles to aid him in obtaining air. A general anesthetic abolishes the activity of the voluntary muscles of respiration, and so might cause suffocation. In such cases the operation can be done with fair satisfaction after the injection of eucain or after infiltrating the superficial tissues of the chest wall with Schleich's fluid, or, what is better, preliminary aspiration can be performed. Aspiration will permit of the subsequent administration of a general anesthetic. The patient on whom thoracotomy is to be performed is placed supine, the diseased side being at or over the edge of the table. He must never be placed on the sound side, because he breathes only with that side, and pressure on it may be dangerous.

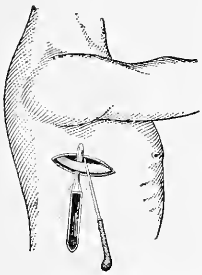


Fig. 427.—Resection of a rib (Esmarch and Kowalzig).

The arm of the diseased side should be elevated to a right angle with the body. If the surgeon desires to obtain only intercostal drainage, he should make a longitudinal incision about three inches in length at the upper border of the sixth or seventh rib, and the middle of this incision should correspond to the midaxillary line. This incision is carried, layer by layer, to the pleura. If, as will usually be the case, he wishes to remove a portion of a rib, he will make an incision about three inches in length directly upon the outer surface of the rib he wishes to remove, and the middle of this incision corresponds to the midaxillary line. Some surgeons resect a portion of the fifth rib, some remove a bit of the eighth rib, and Munro * shows that at the level of the eighth rib there is no danger of injuring the diaphragm. By many operators a portion of the seventh or eighth rib is removed in front of the line of the posterior axillary fold.

I agree with Hutton that a portion of the sixth rib in the midaxillary line should be removed.† The reasons given by Hutton for the selection of this rib are: (1) It is over the portion of the lung which expands last. An empyema is drained only partly by gravity, and the fluid is really forced out and the cavity obliterated by lung expansion. If an incision is made anterior or posterior to this point, the expanding lung will block the drainage-opening, and a pus-cavity without drainage will remain in the midaxillary

* Medical News, Sept. 2, 1899.
† See W. Menzies Hutton on "Empyema," in Brit. Med. Jour., Oct. 29, 1898.

line. (2) Such an incision permits a patient to lie on his back without making pressure on the drainage-tube.

The periosteum of the outer surface of the rib must be divided in the same direction as the superficial incision. The exposed rib is stripped of periosteum front and back by means of a periosteal separator, and with the periosteum at the lower border of the rib the intercostal artery is lifted out of harm's way. The rib can be divided by means of cutting forceps, a chain-saw, or a Gigli saw. I prefer a costotome, as it accomplishes the section most rapidly. The usual method is to push a periosteal separator under the rib, and saw the bone in two places by means of a metacarpal saw (Fig. 427). An inch or more of the rib should be removed. The intercostal artery is ligated at each end of the incision, the periosteum is removed, and the pleura is opened. The object of removing the periosteum is to prevent the rapid formation of bone which might narrow the opening and interfere with drainage. The actual opening of the pleura is carried out in the same way in intercostal incision and after rib-resection. A grooved director is pushed into the pleural sac, and the opening is enlarged by means of the forceps and the finger.

The finger removes all masses of tuberculous material or aplastic lymph within reach. If the finger finds the lung firmly bound down by dense adhesions so that it cannot expand, simple rib-resection will not cure the patient, and Estlander's, Schede's, or Fowler's operation should be done. Some surgeons advocate immediate irrigation after opening an acute empyema, but this procedure is unsafe. It is true that in most cases irrigation does no harm, but in no case will it sterilize the cavity, and in some cases it is very dangerous. The pleura is very susceptible to the action of irritants. This is especially true of young children. It happens occasionally that the injection of the blandest fluid is followed by intense dyspnea, great shock, disturbances of respiration and circulation, convulsions, and even death (Quénu). The convulsions which occasionally follow pleural irrigation were called by de Cerenville *pleural epilepsy*. In putrid empyema it is proper to irrigate. Irrigation will remove part of the actively poisonous putrid matter, and the retention of putrid matter is a greater danger than irrigation. It was formerly a common custom to make a counter-opening by cutting down upon the long probe pushed against the chest-wall after being introduced through the incision, but a counter-opening is of no particular use. A drainage-tube about two inches in length is introduced and stitched in place. The tube must not be long enough to touch against the lung. A safety-pin is clamped upon the tube to keep it from slipping into the chest. A tape should be fastened to each side of the tube and tied about the chest to prevent it from slipping out. Arrest bleeding, suture the skin, dress with gauze, wood-wool, and a binder, and have the dressings changed as soon as they become soaked at one point. Several times a day change the patient's position. At each change of dressings direct him to lie on the diseased side with the foot of the bed raised for half an hour. Healing takes place by ascent of the diaphragm, expansion of the lung, and retraction of the chest-wall. Expansion of the lung is favored by expiratory acts; hence cause the patient several times a day to blow through a rubber tube into a one gallon Woulff bottle filled with water. The water is blown into another bottle at-

tached to the first by a tube. Remove the drainage-tube when the discharge becomes thin and scanty (about the eighth or tenth day, as a rule). If an empyema ceases to improve and remains stationary for months after it has been drained, firm adhesions exist. If after one year has passed a cavity still exists and there is a flow of pus, the surgeon must perform the operation of Schede, Estlander, Fowler, or Ransohoff.

Thoracoplasty (**Estlander's operation**) is employed in old cases of empyema in which drainage has failed, and in cases with retracted chest-wall, collapsed lung, thickened pleura, and cavities whose rigid walls will not collapse. The procedure recognizes the fact that after pus is evacuated, if the lung is adherent, it cannot expand to fill the space once occupied by fluid, and that the rigid chest-wall cannot fall in as a substitute for the lung. It seeks to destroy the rigidity of the chest-wall and to permit it to collapse and thus obliterate the cavity of the empyema. When the surgeon resects a rib and finds a cavity with uncollapsible walls, or a lung bound down with firm adhesions, he should perform thoracoplasty. This operation causes the obliteration of the cavity by collapsing that portion of the chest-wall overlying it. The cavity is usually in the upper or central part of the pleural space. The instruments required are the same as those for resection of a rib. The position is the same as that for rib-resection. The length of the incision depends on the size of the cavity. The surgeon usually removes portions of the second, third, fourth, fifth, sixth, and seventh ribs. Make a transverse incision along the center of an intercostal space, and through this incision remove the ribs above and below by the method set forth on page 784 (the removal of six ribs will require three incisions). Instead of this incision, we can make a vertical incision or a U-shaped flap. Always take away the periosteum in order to prevent reproduction of the ribs. In cavities which are surrounded by firm adhesions, and in old cases in which the pleura is greatly thickened, irrigation is safe. If the cavity is small, it should be packed with iodoform gauze and allowed to granulate; if large, it should be drained by a large tube, the skin being sutured by silkworm-gut.

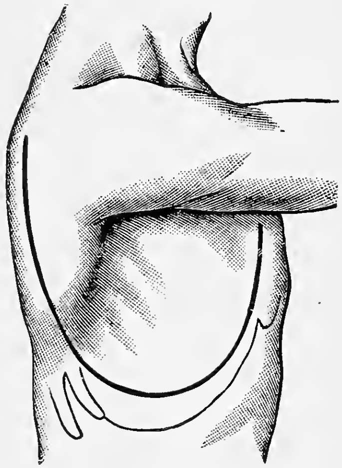


Fig. 428.—Incision for Schede's operation of thoracoplasty (Esmarch and Kowalzig).

Schede's Operation.—Schede showed that when the pleura is much thickened, even Estlander's operation will not permit the chest-wall to collapse and fill the cavity once occupied by the fluid. The instruments used are the same as for Estlander's operation. A U-shaped flap is made from the level of the axilla in front to the level of the second rib and between the scapula and spine behind. The lowest level of this incision corresponds to the lowest limit of the pleura (Fig. 428). The flap is loosened and raised and the scapula is lifted with it. The ribs from the second rib down and from the costal cartilages to the tubercles are removed, along with the inter-

costal muscles and the pleura. This is accomplished by cutting with bone-shears and scissors. Hemorrhage is arrested. The pleura is cureted. A drainage-tube or a piece of iodoform gauze is introduced, and the raw flap is laid against the visceral layer of the pleura. The superficial incision is sutured, except at the point where the tube of the gauze emerges. The mortality from Schede's operation is from 15 to 20 per cent.

Total Pleurectomy or Pulmonary Decortication (Fowler's Operation).—In the spring of 1893 de Lorme performed some experiments on dogs looking to the development of the operation. In October, 1893, George Ryerson Fowler, having no knowledge of de Lorme's investigation, operated on a man and cured a chronic empyema. The French surgeon's first operation was months later. Extensive rib-resection is practised. This is better than de Lorme's trap-door flap, which causes pneumothorax. The thickened pleura is removed from the chest-wall, lung, pericardium, and diaphragm, any sinus is extirpated, and all granulation tissue is taken away. Fowler makes a report of 30 cases. Eleven cases were completely cured. In 17 cases the empyema was cured, but 6 of them had tuberculosis. There were 3 deaths. The combined statistics of Fowler, de Lorme, and Cestan show 35.7 per cent. cured, 19.7 per cent. improved, 33.9 per cent. not cured, and 10 per cent. died (Kurpjweit, in "Beiträge zur klinischen Chirurgie," Bd. xxxiii, H. 3).

Discission of the Pulmonary Pleura (Ransohoff's Operation).—This operation can be employed when decortication is impossible, and it may be used as a substitute for decortication in certain cases. It is founded on the observation that if the thickened pleura over a shrunken lung is incised the cut widens with each respiration and quickly becomes a groove (Ransohoff, in "Annals of Surgery," April, 1906). The pulmonary pleura is divided by numerous parallel incisions one-quarter of an inch apart, and then similar incisions are made to cross these. An incision is also carried through the costal side of the angle of reflection of the pulmonary and costal pleura.

Pneumotomy for Abscess of the Lung.—Give chloroform or use a local anesthetic. Place the patient recumbent with the shoulders a little raised. Make a U-shaped flap over the seat of disease. Resect a portion of a rib. If it is found that adhesions do not exist between the pulmonary and costal layers of the pleura, stitch these layers together with catgut and postpone further operation for forty-eight hours. If adhesions exist, proceed at once. Chloroform can be put aside when pleura is exposed. Fowler calls attention to the fact that lung tissue is so insensitive that the administration of an anesthetic can be suspended as soon as the pleura has been opened. Incise the agglutinated layers of the pleura, and pass an aspirating needle into the lung in various directions. When the abscess is located, open it with the cautery. Carry the Paquelin cautery slowly into the lung in the direction of the abscess-cavity. The cautery knife should be at a dull-red heat.

When the cautery opens the cavity of the abscess, withdraw the instrument and insert a drainage-tube, and suture the flap of superficial tissue. If the abscess is not found after one or two punctures with the aspirating needle, abandon the attempt.

Tuffier explores for an abscess by what he calls *décollement of the parietal pleura*. He exposes the parietal layer of the pleura, passes his hand between this layer and the chest-wall, strips the pleura off over a considerable area, and is able to feel the lung below and thus determine its condition.

XXVI. DISEASES AND INJURIES OF THE UPPER DIGESTIVE TRACT.

Injuries and Diseases of the Face, Nose, Mouth, Salivary Glands, Tongue, Jaws, and Esophagus.—Wounds of the Salivary Glands.—An aseptic wound usually heals and rarely results in a salivary fistula, although after healing it is not unusual for an encysted collection of saliva to gather under the skin. Such a collection of saliva, if it does not disappear spontaneously, can usually be gotten rid of by continued pressure. When a wound of a salivary gland is infected, a single fistula or multiple fistulæ may be left as a legacy. A salivary fistula is very annoying, because the saliva flows constantly. A fistula usually heals spontaneously after a long time, but healing can be quickly brought about by touching the orifice with the Paquelin cautery.

Wound of Steno's duct is apt to cause a fistula, and the condition is often difficult to cure. In this condition, when the duct was cut across, the central end grows fast to the cutaneous surface. Fistula of Steno's duct may also be caused by obstruction and rupture of the duct and by suppurative or gangrenous processes.

In wounds of the duct the ends should be brought as near together as possible with catgut sutures which do not enter the lumen of the duct; an incision should be made through the mucous membrane to permit drainage of saliva, if the mucous membrane is not already opened, and the skin should be sutured. In some cases the central end of the duct may be carried into the mouth and sutured to the mucous membrane. If, after an injury of Steno's duct, saliva gathers under the skin, make an incision through the mucous membrane, to give a route for the saliva to enter the mouth, and apply pressure externally. When a fistula forms, it may be cured by the cautery and pressure, but, if the peripheral portion of the duct is obliterated, which can be determined with a sound, an operation must be performed. Tillmanns advocates cutting out the external portion of the fistula by two elliptical incisions. A trocar is passed through the bottom of the wound in two places, about half a centimeter apart; a piece of stout silk is drawn through the holes and tied tightly and the superficial incision is closed. The silk cuts through and makes an internal fistula. Another method is to make an incision, find and isolate the central end of the duct, open the mucous membrane, suture the duct to it, and close the superficial wound.

Fig. 429.—De Guise's operation for salivary fistula (Esmarch and Kowalzig).

De Guise's operation is shown in Fig. 429. He threads a piece of silk through two needles and carries the needles into the mouth so that the silk will embrace a bit of tissue half a centimeter in length. The silk is tied tightly

within the mouth, the ends are cut off, and the margins of the fistula at the surface are freshened and sutured.

Parotitis.—Mumps, or epidemic parotiditis, is treated by the physician. In this condition the submaxillary and sublingual glands are usually involved as well as the parotid. In pyemia metastatic abscesses may form in the parotid gland. Great swelling arises, respiration is often embarrassed, and early incision is necessary. Parotid inflammation other than mumps is usually due to the passage of bacteria up Steno's duct, the source of the microbes being a foul condition of the mouth, particularly noma or stomatitis. Hence such inflammation is most common during the existence of acute infectious diseases and sepsis. Suppuration or even gangrene may occur. As a rule, only one gland is attacked, but both may be. It is a well-known fact that occasionally, after an abdominal operation, non-suppurative inflammation of the parotid gland occurs. The form of parotitis may, of course, be due to septic metastasis and sometimes is, but I am satisfied that most cases result from foul mouths, the infection ascending from the mouth along the duct. Oral cleanliness strongly tends to prevent the so-called "*sympathetic*" *parotitis*. In non-suppurative parotitis there are pain, tenderness, obvious swelling, and hyperemia of the skin, and it is difficult to open the mouth or swallow. When suppuration occurs, all of the above symptoms are intensified, the discoloration becomes dusky, the skin becomes shiny and edematous, the constitutional symptoms of pus-formation exist, and there is usually delirium.

Treatment.—In the non-suppurative form apply an ice-bag over the gland for the first twenty-four hours and then substitute heat. Wash the mouth out frequently with an antiseptic wash and apply ichthyol and lanolin to the swollen region. In the suppurative form make several openings by Hilton's method, seeking for points of softening; apply hot antiseptic fomentations, wash the mouth frequently with an antiseptic fluid, and combat sepsis by appropriate constitutional treatment.

Salivary Concretions.—The saliva contains in solution certain salts which may deposit. Deposited on the teeth, they constitute tartar. Deposited in a salivary duct or the acini of a gland they constitute a calculus. The salts deposited are carbonate and phosphate of lime. A calculus may consist purely of these two salts or there may be a foreign-body nucleus. A calculus is a possible result of an inflammation which blocks, constricts, or roughens a duct or acinus and decomposes saliva. Small concretions are often passed. Concretions the size of a bean are retained. A concretion may attain the size of an English walnut. A concretion does not block a duct continuously, but does so now and then, causing swelling and tenderness of the gland. A retained calculus can be palpated by a finger in the mouth and a finger externally.

Treatment.—A calculus in a duct is extracted by making an incision through the mucous membrane. If a very large calculus forms in the submaxillary gland, the gland should be removed through an external incision.

Harelip and Cleft Palate.—*Harelip* is a congenital cleft in the upper lip due to defective development. *Cleft palate* is a congenital fissure in the soft palate or in both the hard and soft palates. In harelip the cleft is usually complete, through the entire lip into the nostril, but in rare cases it may show only as a furrow in the mucous edge or as a split from the nostril

partly into the lip. It is most common on the left side. In double harelip the central portion of the lip is often adherent to the tip of the nose. Double harelip may be free from complication, but is often associated with a malformation of the alveolus and palate. Median harelip is exceedingly rare. In cleft palate the septum of the nose is usually adherent to the palatine process opposite the side upon which the fissure exists. In those rare cases of cleft palate double in front, the nasal septum is attached only to the premaxillary bone, and the premaxillary is not attached at all to the superior maxillary bone. In harelip there is frequently a cleft in the alveolus, and almost always flattening of the corresponding side of the nose. Harelip is often associated with cleft palate, talipes, and other deformities. It is a great deformity, and interferes with sucking, swallowing, and articulation.

Operation for harelip should be performed between the third and sixth months of life in a child in good health, free from stomach trouble, cough, or coryza, but operation is not advisable in the early weeks of life. Always, if possible, operate before dentition begins (seventh month). If the child is in poor health, postpone the operation until restoration has so far advanced as to render operation safe. While waiting for operation be sure the child is getting enough food. It it cannot suck, feed it with a spoon. If a cleft exists in the palate, operate first upon the lip, because the pressure of the parts after the edges of the gap are approximated aids in the closure of the bony cleft. Cleft palate interferes with sucking, deglutition, mastication, and articulation. In severe cases the food passes into the nose and excites inflammation. Loss of control of the palate-muscles always exists, and liquids and solids are liable to pass into the windpipe. Clefts in the hard palate should not be operated on until the second year, but should be operated upon then, otherwise speech will be permanently affected. Some surgeons refuse to operate until the tenth or twelfth year, but operation done this late will not correct speech-defect. The patient at the period of operation should be well and free from cough. In many cases the passage of food and drink into the nose can largely be prevented by the use of a diaphragm.

Operation for Harelip.—The instruments required are a tenotome and scalpel, toothed forceps, hemostatic forceps, scissors curved on the flat and pointed, straight blunt-pointed scissors, needles (straight and curved), silver wire or silkworm-gut and silk sutures, a mouth-gag and tongue-forceps, a needle-holder and sequestrum-forceps, each blade protected by a rubber tube. Wrap the child in a sheet; place it in the Trendelenburg position, and rest the head upon a sand-pillow. The surgeon stands to the right side of the patient. Ether or chloroform is given. For *single harelip*, separate with the scissors the upper lip from the bone on each side of the cleft until approximation of the cleft can be effected without tension. If the premaxillary bone of one side projects more than its fellow, grasp it with sequestrum-forceps and bend it back (Jacobson and Treves). Clamp the upper lip at each angle of the mouth to prevent hemorrhage. If the edges are of equal or nearly equal length, and if the gap is not very wide, perform Malgaigne's operation. This is performed as follows: a flap is detached on each side, the detachment beginning at the upper angle of the gap; each flap is detached above, but remains attached below. The flaps are separated from the bone, and are drawn downward so as to form a prominence at the vermilion border (Fig. 430). If the edges are pared so

that in closure the vermilion border is even, when the parts are healed a gutter will be visible at the line of union. The edges are approximated by an assistant, and silkworm-gut sutures or silver wires are passed by means of a straight needle. Each suture goes down to the mucous membrane. The first suture is passed through the middle of the lip, one-third of an inch from the cleft. Three or four main sutures are passed through the thickness of the lip, and are tied and cut off. Two or three fine silk or catgut sutures are passed by a curved needle through the vermilion border of the lip and the mucous membrane of the mouth, and are tied and cut off. A small piece of gauze is placed over the lip and is held in place by straps of rubber plaster. After operation prevent the child crying by feeding it often and giving it small doses of laudanum. Heath orders two drops of laudanum in one ounce of distilled water, a teaspoonful to be given every two or three hours. About the sixth day one-half the sutures are taken out, and on the eighth or ninth day the remaining ones are removed. In many cases no further procedure is necessary, but if after some weeks the prominence at the lip-border does not shrink, it can be readily clipped away. Harelip-pins are not used at the present time, and are not needed if the lip is well separated from the bone. If the edges of the cleft are of unequal length, Edmund Owen's operation can be performed (see

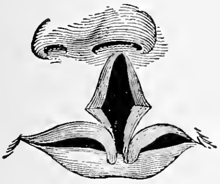


Fig. 430.—Malgaigne's operation for harelip.

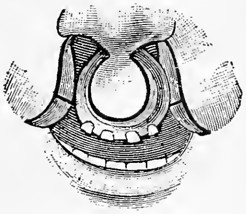


Fig. 431.—Incisions for double harelip (Esmarch and Kowalzig).

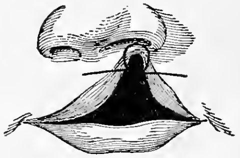


Fig. 432.—Mirault's operation for single harelip (Esmarch).

below, under Double Harelip), or we can perform Mirault's operation, as shown in Fig. 432.

In *double harelip* the operation is similar to that for single harelip. If the intervening piece is vertical and is covered with healthy skin, complete each operation as for single harelip, closing both fissures at once with silver wire in a strong, healthy child, closing them at intervals of three weeks in one not so lusty (Fig. 431). Excise the septum if it is deformed. The premaxillary bone should in most instances be removed, the skin over it being preserved. Sir Wm. Fergusson was accustomed to incise the mucous membrane and shell out this bone. The premaxillary bone can be forced back into line, being held, if necessary, by catgut suture of the periosteum; but if saved, it is liable to necrose and its teeth soon decay. Heath removes this bone two weeks before operating on the lip. If there is much hemorrhage after removal of the bone, arrest it with a hot wire or with Horsley's wax. Fig. 431 shows incisions for double harelip. Edmund Owen's operation is very useful (Figs. 433 and 434). In this operation very thick flaps are cut. The prolabium and incisive bone are removed. The flaps are cut as shown, Fig. 433, on one side by a line *ab*, and on the other side the piece *cde* is removed. *a* is brought to *e*, *b* is brought to *d*, *f* is brought to *c*, and sutures are applied (Fig. 434).

Operation for Cleft Palate.—It is true that during the early years of growth a cleft diminishes in size and diminishes particularly if a harelip is closed; but to wait too long before we operate means permanent speech-impairment. Bony clefts should be operated upon during the second year. Clefts of the soft palate only may be operated upon during the first six months of life. If both the hard and soft palates are cleft, close both at one operation. In an ill-nourished child in which the covering of the bone is obviously thin, it is best to postpone any operation upon a bony cleft until the end of the third year. I agree with Berry that operation is justifiable up to the age of twenty, but early operation is highly desirable. Edmund Owen has recently put forth a convincing plea for early operation.* He says he is operating earlier and earlier, and quotes Chilton as the gentleman who led him to do so. Owen maintains that if speech is to be improved, operation must be done early, and he formulates some very valuable rules for preparation and care. I have never been convinced that operation in early infancy is entirely safe and has any notable advantages. If a person is not operated upon for a hard-palate cleft, he must wear an obturator made by a dentist. In preparing a child for operation I follow Edmund Owen's rules, viz.: Have the child

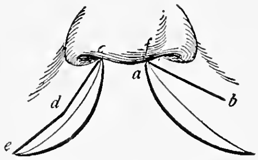


Fig. 433.—Double harelip, the prolabium and incisive bone having been removed (Owen).

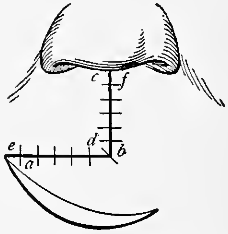


Fig. 434.—The two sides of the lip drawn together and secured by sutures (Owen).

in the best condition, free from cough and stomach disorder. Operate in summer. Place the child under the charge of a nurse several days before the operation.

Operation for Suture of the Soft Palate (*Staphylorrhaphy*).—The operation of staphylorrhaphy, which is applied to clefts of the soft palate alone, is a comparatively easy procedure. In performing this operation the patient should be anesthetized and be placed in the Trendelenburg position, or else with the head hanging over the end of the operating table. The mouth is held open with Whitehead's gag, and an assistant holds an electric light and a reflector to illuminate the oral cavity. If the patient is not a young child, the operation may be done under cocain, with the subject sitting erect in a chair and the surgeon sitting directly in front of him.

The surgeon should have at hand several knives of different shape. The double-edged, pointed knife is an excellent one for freshening the margins of the palate. Special forms of needle-holders have been devised for the purpose of carrying the needle. The heavy, curved, sharp-pointed bistoury is the best instrument for dividing the muscles of the palate; and a

* Lancet, Jan. 4, 1896.

sharp hook should be at hand, in order to catch the edge of the cleft, if necessary.

The surgeon first of all separates the soft palate from the posterior edge of the palate bones and from the nasal mucous membrane (Fig. 435). This step is necessary in order that the edges may meet in the middle line (Berry). One edge of the cleft uvula is now grasped with a pair of forceps or a sharp hook, and is pulled upon to make it tense. This edge is then pared from below upward, the piece being continuous from the base to the apex of the cleft. This piece is severed, and then the other margin of the cleft is pared in the same way. It is now advisable to free the margins of the wound from tension. These lateral incisions not only relieve tension, but temporarily paralyze the soft palate. Figs. 436 and 437 show the incisions as recommended by Berry. These incisions divide the tendons of the levator palati and the palatopharyngeus muscles, and temporarily paralyze the palate. The impair-

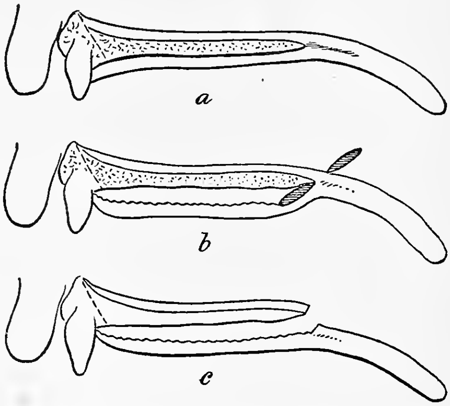


Fig. 435.—Longitudinal vertical section through the hard and soft palates. *a*, Before operation. *b*, Palatine mucoperiosteum detached and brought down. Blades of scissors introduced to cut attachment of soft palate to the bony palate and to the nasal mucous membrane. *c*, The same after the cut has been made and the soft palate thus brought down (Berry).

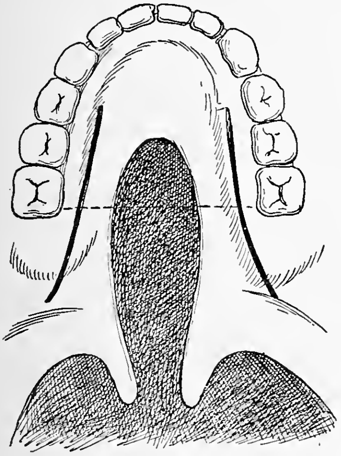


Fig. 436.—Cleft of soft and part of hard palate. Shows exact situation in which the lateral incisions should be made (Berry).

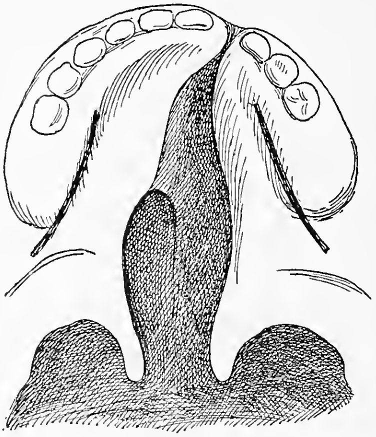


Fig. 437.—Semi-diagrammatic view of complete left cleft palate. The septum nasi is attached to the palate on the (patient's) right side. The mucous membrane on the left side of the septum may be detached and brought down if necessary to help in the closure of the anterior half of the cleft. Shows exact situation in which the lateral incisions should be made (Berry).

ment of palate function is not permanent, as the nerves to the muscles are not cut.

The sutures are inserted by means of a special needle-holder, so arranged that the needle may be directed in many different positions when grasped. The sutures are introduced from below upward, silkworm-gut being used for the uvula and the lower part of the velum, and silver wire for the balance of the cleft. Each suture, as it is passed, is so tied or twisted, and it is not cut off until the next suture is inserted, and thus serves as a handle. If there is too much tension to allow of the sutures being tied as they are inserted, all the sutures are passed and lightly twisted before one is tied.

Closure of Clefts in the Hard Palate (*Uranoplasty*).—As previously stated, the best time to perform these operations is during the second year of life. In some few cases we postpone the operation until the end of the third year. If the child learns to talk with the palate cleft, articulation will never be very greatly improved, even by operation. One should, therefore, try to operate before the child learns to talk. Even after the closure of the cleft the speech does not become entirely normal; in fact, as Berry says, it never becomes even very good. One should exercise the greatest care in forming the soft palate, because good articulation is largely dependent upon a well-formed soft palate (Berry, in "Brit. Med. Jour.," Oct. 7, 1905). The surgeon may be able to close the entire gap at one operation; or, owing to undue tension, he may be forced to close it but partly, completing the closure at some subsequent period.

The operation that, to my mind, is the best is one that uses the soft tissues alone—such a one as is advised by Berry. I have entirely abandoned the operation of wedging the bone over with a chisel. I am satisfied that it is far more dangerous than is the other method; it is more liable to fail; and, if it fails because of necrosis, it is difficult or impossible to cure the defect by a second operation. The essence of a successful operation, using the soft tissues alone, is, as Berry insists, the complete detachment of the soft palate from the posterior edge of the palate-bone (Fig. 435); because, if one fails to secure this, the edges of the gap will not approximate in the median line. One should also separate the soft palate from the mucous membrane of the nose (Fig. 435).

A second very important point is the imperative necessity of making incisions to the sides, to relieve tension, and to paralyze for a time the soft palate. The incisions, as recommended by Berry, are shown in Figs. 436 and 437. The cut is close to the teeth, and is taken as far posterior as the middle of the soft palate, at the junction of that structure with the lateral pharyngeal wall. In this cut there is some risk of dividing the anterior palatine artery; but hemorrhage from this vessel can be arrested by pressure. Berry insists that the incision need not go forward more than the level of one or two premolar teeth; or, in older children, to the first or second molars. The edges of the fissure are pared on each side, from the tip of the uvula to the top of the gap. Strips of the mucoperiosteum are lifted up on each side of the gap and shifted toward the cleft, and at this stage the posterior border of the soft palate is separated from the posterior border of the hard palate (Fig. 435).

The parts are sutured with silver wire, following the advice of Edmund

Owen to twist and cut each wire, leaving an end one-eighth of an inch in length. This procedure causes the child to keep his tongue from the suture line.

For the first twenty-four hours only water is given. After this period the patient is fed with jelly and liquids. Only fluid or soft food is used for two or three weeks. Talking is forbidden. A day or two after the operation the child should be taken into the open air and kept in it all day. As Owen shows, this greatly stimulates vital resistance and lessens, to a considerable extent, the danger of sloughing of the suture line. The mouth is washed frequently, and always after taking food, with Condy's fluid. The sutures are allowed to remain between two and three weeks.

Fergusson's Operation.—In this operation the mucous edges are pared, the bones are drilled for wires, and the sutures are inserted, but not tied. An incision is made on each side of the cleft down to the bone, each incision being midway between the cleft and the corresponding alveolus. The bone is divided on each side, by means of a chisel, to the full length of the incision; and the chisel is used as a lever to force each half of the bone toward the gap. The sutures are tied, and each lateral incision is plugged with iodoform gauze.

Brophy's Operation.—This operation is employed particularly for children under three months of age, and cannot be used when the child is over six months. In this operation the palate is closed before the harelip is touched. Operating at this time, the bones are soft, and by leaving the harelip untouched the surgeon has more room to work. The author of the operation believes that when it is performed at this early age the palate-muscles do not atrophy, but develop, and that the patient does not form the evil habit of talking through the nose.

In performing this operation the very strong-handled needles of Brophy are necessary. The patient is anesthetized and put into the Trendelenburg position and a strong piece of silk is put through the tip of the tongue as a traction-suture. The edges of the cleft in the hard palate are pared, a little of the bone being taken away with the paring. Then the edges of the cleft in the soft palate are pared. The needle is threaded with strong silk: the cheek is lifted; and the threaded needle is forced through the superior maxillary bone from without inward, starting just back of the malar process and just above the palate. As the needle shows in the cleft the thread is picked up with a pair of forceps, and the needle is pulled out, the loop of thread remaining in the cleft. Through a part of the opposite superior maxillary corresponding with this first point of entrance the needle is entered again and another loop is got into the cleft. The second loop is caught into the first loop, and when the former is pulled out, it carries the latter with it. This thread now passes through both the superior maxillary bones and usually through the nasal septum as well. This thread is used to pull a piece of strong silver wire through. One other silver wire is introduced in the same manner more to the front. The silver wire ends are threaded through perforated lead plates, which fit the external outline of the bones on each side. The wires are tightened and twisted. For instance, on one side, the end of the anterior wire is twisted to the end of the posterior wire, and so on. The thumbs are used to jam the two ends of the maxillary bones forcibly together, thus closing the cleft, and then the wires are twisted more firmly to hold the edges in contact. The cleft in the soft palate is then sutured, although the surgeon may

deem it advisable to wait one day before doing so. After the palate heals the harelip is closed.

Carcinoma of the Lower Lip.—Cancer commonly arises in the lower lip, very rarely in the upper lip. Males suffer frequently, but females are not very often attacked. In some cases it seems to arise in smokers at the point on the lip where the pipe habitually rested. A short-stemmed clay pipe, which grows hot when it is smoked, is particularly apt to lead to the growth of cancer. The region of the lip which is most liable to cancer is the junction of the skin and mucous membrane. The growth may begin in a fissure or abrasion, may start in an eczematous area, but most frequently arises as an indurated area which quickly ulcerates. After a cancer has existed for a variable time the submental and submaxillary lymphatic glands become diseased. These glands are always involved within three months of the beginning of the cancer. In a case of my own they were found to contain carcinoma cells in less than three months after the origin of the carcinoma of the lip. This involvement cannot be detected by external manipulation in the earliest stages; hence it is not proper to conclude that the glandular involvement is absent simply because it cannot be palpated. It occasionally happens that glands enlarge because of septic absorption, and this enlargement may even precede carcinomatous involvement. From an operative point of view the glands should always be regarded as carcinomatous. If cancer is not operated upon, it destroys the lip, involves the glands of the neck extensively, the floor of the mouth, the periosteum and the lower jaw, and produces death in from three to five years. If the jaw is involved, the prognosis is bad and it is practically hopeless if the floor of the mouth is involved.

Treatment.—The treatment consists in the early and thorough removal of the growth with the knife, and also in the removal of the fatty tissue and gland from the submaxillary triangles and from the submental region. The growth must be thoroughly removed—that is, the incision must be at least half an inch wide of the disease. For many years a favorite operation has been the V-shaped incision, the skin-edges being sutured by silkworm-gut, the sutures being passed almost to the mucous membrane and being inserted so as to compress the vessels when tied, and the mucous membrane being sutured with fine silk or catgut. The V-shaped incision should be used only for a very small and very recent growth. After the removal of the growth from the lip a vertical incision is made from the point of the V over the cricoid cartilage, and from the origin of this incision incisions are made in each direction along the under surface of the body of the jaw. The glandular area is thus exposed, and after the removal of the fat and glands the wound is sutured with silkworm-gut. Far better than the V-shaped incision is the operation devised by W. W. Grant, of Denver.* In this operation the growth is removed and cheiloplasty is performed.

Grant's Operation for Cancer of the Lip.—This operation gives a useful mouth and a more natural-looking lip than does the ordinary operation, and there is decidedly less tension on the suture-line. Furthermore, the suture-line in a man is soon covered with a beard. The procedure has great advantages over the ordinary V-shaped operation, which greatly lessens the size of the mouth, making it what is known as a sucker-mouth; and the new lip is rigid and ugly.

* Medical Record, May 27, 1899.

In Grant's operation two vertical incisions are made, one on each side of the growth, and these are connected with a horizontal incision at the base (Figs. 438 and 439). Thus, a quadrangular gap is formed, which must be filled by flaps. An incision is made on each side from each inferior angle of the wound, obliquely downward and backward beneath the maxilla, on a line about midway between the angle of that line and the apex of the chin (Fig. 438). Its further extension is determined by the amount of lip removed and by the degree of glandular involvement.

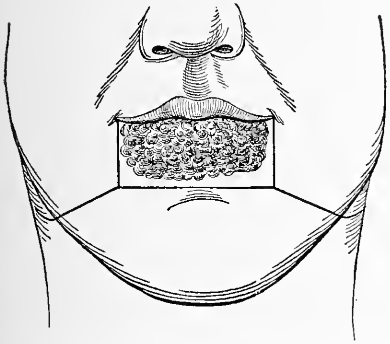


Fig. 438.—Grant's method for removal of carcinoma of the lower lip. The incision.

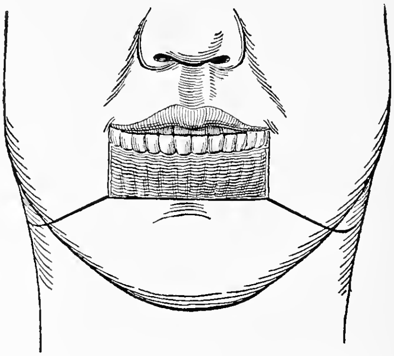


Fig. 439.—Grant's method for removal of carcinoma of the lower lip. Second step. The mass removed.

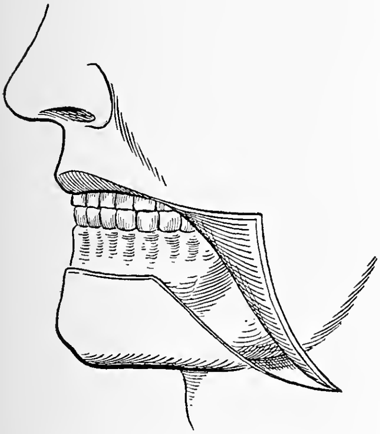


Fig. 440.—Grant's method for removal of carcinoma of the lower lip. Dissection preliminary to suturing.

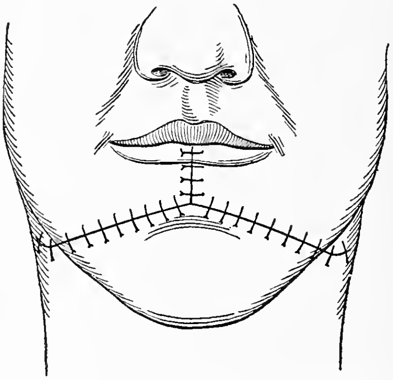


Fig. 441.—Grant's method for removal of carcinoma of the lower lip. The wound sutured.

The submaxillary lymph-glands are removed through these incisions. The glands in the midline, however, beneath the chin may require a separate incision. If the lip is extensively involved, the cheek ought to be completely separated from the inferior maxillary bone to the middle of the masseter muscle (Fig. 440). When the glands have been removed, the triangular flaps are

brought together and united, first of all, in the middle line (Fig. 441). If the tension is marked, owing to the amount of tissue excised, it is wise to insert a traction suture, three-quarters of an inch from the center line, and tie it over pads of gauze covered with oiled muslin. One thus prevents undue tension upon the sutures in the center of the flap. The stitches that unite the cheek posteriorly are inserted and tied, and the entire thickness of the cheek must be included. Silkworm-gut sutures are used.

I have employed this operation repeatedly, and regard it as the most useful method we have for the purpose. Thorough removal of the carcinoma of the lip and of the related glands will cure from 60 to 70 per cent. of cases.

Carbuncle of the Upper Lip.—In contrast to carbuncle in other regions of the body, facial and lingual carbuncle is most common in young persons. The condition is due to staphylococcus infection and begins as a papule. Numerous pustules appear, and sloughing usually takes place. There may or may not be serious constitutional involvement. The condition is very dangerous, as thrombophlebitis may arise and track up into the cranium. I have known two persons to die from carbuncle of the lip.

Treatment.—Make a crucial incision, cutting away the corners and edges with scissors. Scrape out the carbuncle with a sharp and strong curet, swab with pure carbolic acid, pack with iodoform gauze, and dress with antiseptic poultices.

Tongue-tie (*congenital ankyloglossia* or *adherent tongue*) is a congenital shortness of the frenum, the tip of the tongue adhering to the floor of the mouth. It is due to the projecting portion of the tongue being incompletely developed from the tuberculum impar. "In many of the slighter cases the development has merely lagged behind, and will be completed as the child grows after birth" ("Diseases of the Tongue" by Henry T. Butlin. Second edition). The tongue cannot be protruded beyond the incisor teeth. Swallowing is interfered with, and later in life articulation is impeded. It is not very unusual in infants, but in the great majority of cases disappears as the child grows older. Persisting tongue-tie, Butlin says, is one of the rarest of conditions, and my experience is in absolute accord with this—in fact, I have never seen a single case. Many unnecessary or even harmful operations are done for a condition which, if let alone, will usually correct itself. Improper operation may result in fatal hemorrhage or in "swallowing of the tongue." The operation usually done is to tear up the frenum with a thumbnail. This is unsurgical and makes a lacerated wound. A better way is to raise the tip of the tongue to make the bands tense, and then snip with the scissors close to the mucous membrane of the lower jaw. The slit in the handle of the grooved director was placed there to catch the frenum in, but a short frenum will not enter it (Butlin).

Ranula is a retention-cyst of the duct of the submaxillary or the duct of the sublingual gland. A ranula when first formed contains saliva, but after a time the saliva undergoes a change, and in appearance comes to resemble mucus. *Mucous cysts* occur in the floor of the mouth, resulting from obstruction of the ducts of the *mucous glands of Nuhn and Blandin.* These glands lie on each side of the frenum of the tongue. Such a cyst is often spoken of as a ranula. A *cyst of the incisive gland* forms just back of the lower jaw and lifts up the frenum. A true ranula appears upon the floor of the mouth

on one side and pushes the tongue toward the opposite side. The *treatment* of a mucous cyst is by excision of a portion of the cyst-wall and cauterization of the interior with pure carbolic acid; or by cutting a flap from the cyst-wall and stitching it aside so as to keep a permanent opening. Such an operation may cure a genuine ranula, but will often fail. In true ranula an external incision should be made, and through this both the cyst and the gland should be removed. This plan is recommended by Mintz.*

Thyro-lingual or Thyro-glossal Cysts and Sinuses.—In early embryonal life the thyroid gland has a duct which passes from the thyroid isthmus to the foramen cæcum of the dorsum of the tongue. It is known as the thyro-glossal or thyro-lingual duct. The duct runs from the base of the tongue down the mid-line of the neck, connected with the body of the hyoid bone, with the periosteum in front of the bone, and with the thyro-hyoid bursa behind the bone, to the upper portion of the front surface of the trachea, where it bifurcates, each branch passing to a lateral lobe of the thyroid gland. This fetal structure under normal conditions begins to atrophy in the fifth week and closes by the eighth week, the foramen cæcum marking its orifice on the dorsum of the tongue. When the duct is obliterated, it becomes a cord of epithelium. The duct may persist between the foramen cæcum and the hyoid bone, developing, it may be, into a *sublingual dermoid*. The portion behind and below the hyoid may remain and develop into a *subhyoid cyst*. The part inferior to the hyoid may persist, give origin to a cyst which ruptures and constitutes an incomplete *cervical fistula*. The duct may remain open from the mouth and make, by bursting an opening in the neck, an complete cervical fistula. The small diameter of a cervical fistula renders probing to any depth impossible. To determine if a fistula is complete, inject quassia solution into the lower end, and the patient will perhaps experience a bitter taste; or inject a colored fluid which may run from the mouth. Tumors may spring from the duct.

Treatment.—If a thyro-glossal cyst or tumor arises on the dorsum of the tongue and if it is increasing in size and interferes with swallowing and speech, it must be removed through the mouth. A general anesthetic should be given. In some cases preliminary tracheotomy is necessary.

A cyst or tumor about the hyoid bone requires excision, the patient being under the influence of a general anesthetic. A portion of the cyst wall adheres strongly to the posterior surface of the hyoid bone and must be carefully removed even if it is necessary to split the bone to accomplish it. A fistula requires the complete removal of its epithelial-lined walls. No lesser operation will cure. In one case I operated four times before securing success. In order to remove a fistula it is necessary, if it adheres to the posterior portion of the hyoid bone, to separate it carefully, even if the bone requires division to accomplish this.

Carcinoma of the Tongue.—This is one of the most dreadful forms of cancer. It is quite a common disease. In most of the cases I see, it is far advanced when first brought to the surgeon. The only form of cancer which attacks the tongue is epithelioma. It is much more common in men than in women. It is a disease of adult life and is very rare before the age of thirty-five. It begins, as a rule, near the tip, on the side or at the base of the anterior two-thirds of the tongue, as a warty growth, as an ulcer hav-

*Zeitschrift für Chirurgie, March, 1899.

ing at first a papillary structure, as a fissure which indurates, or as an indurated area which ulcerates. The cause of the growth may sometimes be traced to the irritation of a jagged tooth, or to the smoking of a pipe, or to holding nails in the mouth, as is done by those who nail laths. Cancer may follow a chronic inflammation—leukoplakia, for instance. As in cancer of the lip, men are much more frequently affected than women. In most cases the disease spreads rapidly; produces early and extensive glandular involvement; disease of the floor of the mouth; dribbling of saliva; difficulty in masticating, swallowing, and talking; foulness of the breath; severe pain which usually radiates toward the ear, and often a fatal septic trouble. Cases not operated upon usually die within two years. There is a very rare form of carcinoma described by Wölfler, which grows very slowly or even remains latent for years.

One reason why cancer of the tongue grows so rapidly has been pointed out by Heidenhain, of Greifswald. The lingual muscles are contracting almost constantly, and as a result cancer-cells are forced along the lymph-spaces to healthy areas.

Treatment.—A cancer of the tongue should be removed radically at the earliest possible moment. Before any operation is undertaken all stumps of teeth should be extracted. During several days preceding an operation the teeth should be scrubbed twice a day with a brush and soap, and the mouth rinsed with hydrogen peroxid. The nares and nasopharynx should be sprayed with peroxid of hydrogen and then with boric-acid solution every second or third hour when the patient is awake.

In this disease not only the tongue, but also the adjacent lymphatic glands must be removed. The lymph-vessels from the tongue pass to the submaxillary and deep cervical lymphatic glands.

It was my belief until recently that in a very recent and limited case only the glands on the diseased side require removal, but that in an advanced case the glands must be removed from *both sides* of the neck. Experience has convinced me that in any case the glands on both sides should be removed. Kuttner, of Tübingen, has demonstrated that lymph from one side of the tongue may flow to glands on the same side of the neck; but some also may flow to the opposite side of the tongue. Two operations are to be considered: partial removal and complete removal.

Partial Removal of the Tongue.—This operation is restricted to recent cases in which one side only of the anterior portion of the tongue is involved. The operation does not offer as good a chance of cure as complete excision, because lymph containing cancer-cells may have reached the opposite side of the tongue. Even in partial removal the glands should be removed from both sides.

In performing the operation of partial excision introduce a mouth-gag, place a silk ligature on each half of the tip of the tongue, and draw the tongue out of the mouth (Barker). Place the patient in the Trendelenburg position. Split the tongue back in the middle line with the scissors, and loosen the cancerous side from the floor and side of the mouth. Pass a stout silk ligature through the base of the tongue posterior to the cancer. Draw the organ out and cut off the diseased side in front of the ligature but back of the disease. Tie the vessels, remove the constricting and traction threads, and treat subsequently as in cases of complete removal.

Complete Removal of the Tongue (Kocher's Method).—Kocher recommends a preliminary tracheotomy in tongue-excision, but the Trendelenburg position renders this procedure unnecessary so far as fear of the passage of blood into the larynx and trachea is concerned. The instruments required are a scalpel, retractors, a dry dissector, hemostatic and dissecting forceps, a tenaculum, aneurysm-needle, tenaculum forceps, needles, sutures, and scissors. In this operation the patient is placed in the Trendelenburg position, the surgeon standing to the side. Ether or chloroform is given. Ligate the lingual artery on the side opposite to the one where the main incision is to be made. Remove the glands on that side and suture the wound. An incision is then made on the side opposite to that on which the artery was ligated. This incision passes from behind the lobe of the ear, along the anterior edge of the sternocleidomastoid to about the middle of the margin of this muscle. From this point the incision is carried to the level of the hyoid bone and then to the symphysis menti, along the anterior belly of the digastric muscle (Fig. 442). The flap is dissected and turned up; the facial and lingual arteries are ligated; "the submaxillary fossa is evacuated" (Treves); the sublingual and submaxillary glands are removed; the mylohyoid muscle is divided; the mucous membrane is incised close to the jaw, and the tongue, caught with tenaculum-forceps, is drawn through the opening. The tongue is split in the middle with scissors, and the near half is removed, bleeding is arrested, the remaining half of the tongue is cut through, and the vessels are tied. Stitch the mucous membrane of the stump to the mucous membrane of the floor of the mouth with catgut sutures. Kocher does not suture the skin-wound; many surgeons do suture it and employ drainage-tubes. I follow the suggestions of Treves as to after-treatment. Some hours after the operation, when oozing has ceased, dust the mouth-wound with iodoform. The patient, as soon as possible, is propped up in bed, and he must not swallow the discharges if it can be avoided. The mouth, every half hour, is sprayed with peroxid of hydrogen and washed with a carbolic solution (1 : 60). Every three hours after washing the floor of the mouth and the stump the parts should be dried with absorbent cotton and dusted with iodoform. For twenty-four hours after the operation nothing is given by the mouth except a little cracked ice, the patient being fed per rectum. At the end of twenty-four or forty-eight hours some liquid food is given from a feeding-cup. The patient will soon learn to swallow; but if he cannot swallow easily, he is fed with a tube. Treves, in his clear and positive directions for after-treatment, states that nutrient enemata are to be continued until sufficient nourishment is taken by the mouth; that the mouth should be flushed by irrigation, and must be washed immediately after taking food; that morphin is to be avoided; and that the patient can usually leave the hospital in from seven to ten days.

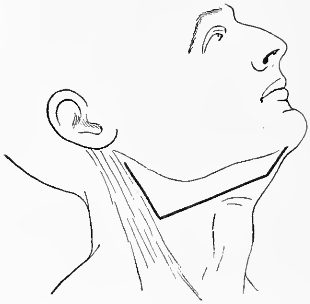


Fig. 442.—Kocher's excision of tongue (Esmarch and Kowalzig).

Whitehead's Operation.—Whitehead removes the entire tongue from within the mouth by the use of scissors. He passes a ligature through the tip, cuts the

frenum, draws the tongue strongly forward, and separates by a series of clips with the scissors. The lingual arteries are tied as cut. "The stump should be kept under control, as regards hemorrhage, by a stout silk ligature passed through the remains of the glosso-epiglottidean fold and retained for twenty-four hours."*

Heath has shown that if the forefinger be passed to the epiglottis and used to "hook forward" the hyoid bone, the lingual arteries are stretched and portions of the tongue can be removed almost without bleeding. It is rarely desirable in Whitehead's operation to remove the glands and the tongue at one séance. To do so increases shock and the danger of death. The rule of procedure set forth by W. Watson Cheyne † is eminently wise. This rule is as follows: If glandular involvement is trivial or not detectable, it is perfectly proper to remove the tongue first, and after a week or so remove the glands. If the glandular involvement is marked, growth in the glands will be much more rapid than growth in the tongue. In such a case the glands should be removed before the tongue, because, if the tongue is removed before the triangles are cleared, in the week or two of waiting the case may become inoperable. In the majority of cases clear out the triangle before removing the tongue, doing the other operation in one or two weeks when the wound in the neck is healed. If the disease in the mouth is far advanced, do both operations at one séance.

Stricture of the Esophagus.—*Fibrous* or *cicatricial* stricture is due to the healing of an ulcer, and results from traumatism, chronic inflammation, syphilis, tuberculosis, chronic ulcer, prolonged vomiting, variola, gout, or to swallowing a corrosive substance or a boiling liquid. It is commonest in the young, and is apt to be situated opposite the cricoid cartilage, at the tracheal bifurcation or near the cardiac end. Cicatricial strictures are usually single, but may be multiple. Stricture following impaction of a foreign body is located at the seat of impaction unless the tube has been injured by efforts at extraction, in which case multiple strictures may exist (Maylard). Strictures which result from swallowing boiling fluid or corrosive liquid are usually very extensive, and may be multiple. Syphilitic stenosis is due to the healing of a gummatous ulceration, but there is nothing characteristic in this kind of stenosis. Tuberculous stenosis is extremely rare.

Symptoms of Cicatricial Stenosis.—The condition may occur at any age. The chief symptom is difficulty in swallowing, at first slight, but becoming more and more pronounced until swallowing is almost or quite impossible. The dysphagia is first manifested to dry solids, then to all solids, and finally to liquids. In some cases vomiting occurs after swallowing. If the stricture is high up, the vomiting is almost immediate; if it is low down, the vomiting is delayed, especially if the canal is dilated above the stricture. From time to time the patient vomits independently of taking food, the ejected matter being saliva. The vomited matter is not bloody. The patient feels weak and hungry, becomes exhausted and emaciated, and suffers from flatulence, gastralgia, and constipation.

There is occasionally slight uneasiness or even pain in the region of the stricture, possibly "about the epigastrium or between the shoulder-blades" (Maylard). The stricture may be located with a bougie and by auscultation over the spine on a line with the supposed obstruction. While a patient

* "American Text-book of Surgery." † The Practitioner, April, 1899.

is swallowing water, the arrest of the fluid at the seat of stricture may be audible. Even if the fluid passes, it will be delayed for a time and the duration of deglutition is thus prolonged. In order to determine the time of deglutition put the ear just below the angle of the left scapula, put a finger on the patient's Adam's apple, and hold a watch in the other hand. Have the patient take a drink of water. Count the time from the moment the Adam's apple begins to rise until the fluid is heard to gurgle into the stomach (Ogston's method). It ordinarily requires four seconds for food to pass from the mouth into the stomach (Maylard). The history of the case is of much importance in diagnosis. The surgeon must inquire about impaction of a foreign body, or swallowing of acids, alkalies, or boiling fluids; and must examine for evidence of syphilis. If there is no history of injury or syphilis, and the patient is over forty years of age, the indications point to cancer rather than cicatricial stenosis. The easy passage of a bougie when the patient is anesthetized shows that spasm is the cause, and not organic disease. Narrowing due to external pressure is marked by positive symptoms of the causative disease.*

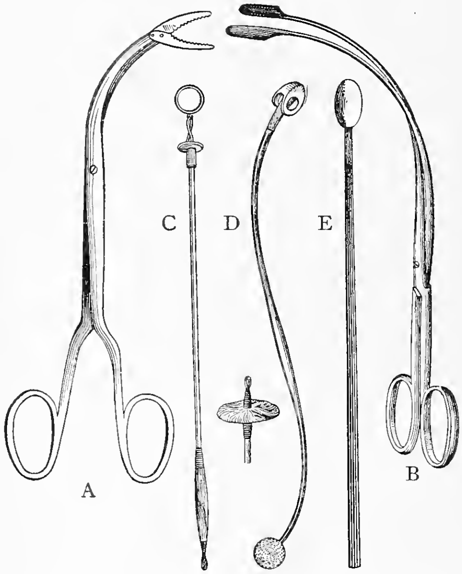


Fig. 443.—Esophageal instruments: A, B, Forceps; C, horsehair probang; D, coin-catcher; E, esophageal bougie.

Treatment.—Thiosinamin is given by some physicians, but I have never seen it accomplish the slightest good. Telleky † recommends it in old scars without inflammation. He makes a 15 per cent. alcoholic solution and injects from half a syringeful to a syringeful at a dose, throwing the fluid beneath the skin between the scapulæ. He uses 20 doses in the course of two weeks. *Gradual dilatation* through the mouth is a method employed for at least a time in almost every case. Begin with the largest bougie which will easily pass. Warm the bougie, oil it, pass it gently, and hold it in position for several minutes, prolonging the time of retention of the bougie as treatment progresses. Pass an instrument every second or third day, gradually increasing the size. If the stenosis involves a considerable portion of the esophagus, gradual dilatation will almost certainly fail to cure.

Symonds advocates the insertion of a tube through the stricture and leaving it in place until there is decided dilatation, and then replacing the tube with a larger instrument. The patient is fed through the tube. Gradual dilatation from below has been practised in cases where a bougie could

* See the excellent article in Maylard's "Surgery of the Alimentary Canal."
† Wien. klin. Woch., Feb. 20, 1902.

not be passed from the mouth. A gastrostomy is performed, and after the fistula has become sound the patient is made to swallow "a shot to which is attached a silk thread" (Maylard). The silk thread is brought out through the fistulous orifice and is attached to a bougie, and the dilating instrument is pulled up through the esophagus. *Forcible dilatation* can be employed through the mouth or through a gastrotomy opening, by means of bougies, tents, or divulsing instruments. *Electrolysis* is used by Fort and others. Some surgeons perform *internal esophagotomy* through the mouth with a special instrument. A fibrous stenosis in the region of the cricoid cartilage

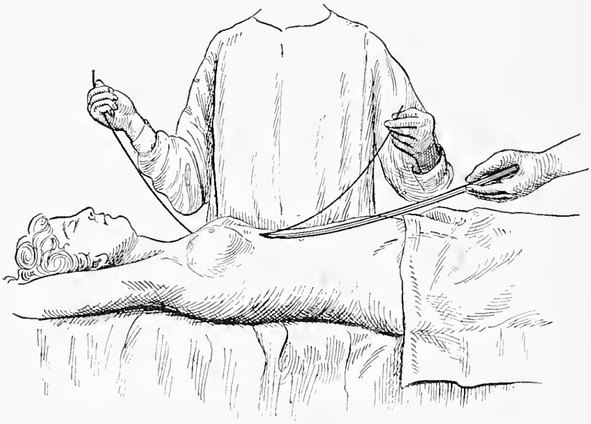


Fig. 444.—Abbe's method of cutting esophageal strictures.

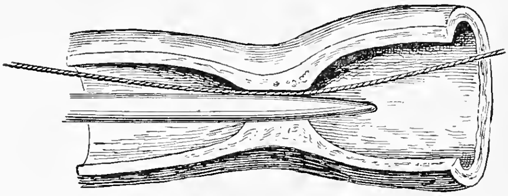


Fig. 445.—The bougie engaged in the stricture while the string-saw is being used.

which is not cured by gradual dilatation should be treated by the operation of *external esophagotomy*. In this operation the stricture is divided by a longitudinal incision; "funnel-shaped retraction of the cut portion is caused by adhesion to the external tissues divided, and it lessens future contraction."* If dilatation fails in the case of a stenosis above the line of the aortic arch, the esophagus may be opened above the stricture (external esophagotomy), a tenotome is introduced through the wound, the stricture is cut and well dilated by the passage of instruments. This operation is known as Gussenbauer's combined esophagotomy.

* W. J. Mayo, Jour. Amer. Med. Assoc., July 29, 1899.

If a stricture is impassable from above, the stomach should be opened and retrograde dilatation be carried out. A firm, non-dilatable stricture in the thoracic portion of the esophagus can be treated by Abbe's method (Figs. 444 and 445). He performs a gastrotomy, passes a conical rubber bougie from the stomach into the mouth, ties a piece of braided silk to the bougie, withdraws the instrument and leaves the silk in place. One end of the silk emerges from the mouth and the other end from the gastrotomy wound. In some cases he opens the stomach and also opens the esophagus above the stricture; one end of the string comes out of the esophagotomy wound and the other end out of the gastrotomy wound. The string is used as a string- or bow-saw, the stricture is divided, the silk is withdrawn, full-sized bougies are passed, and the wound or wounds are sutured.

An operation devised by A. J. Ochsner is thus described by Mayo *: "The anterior wall of the stomach is drawn out of a left oblique incision through the abdominal coverings; a small opening is made into the stomach sufficient in size to introduce the finger. A whalebone probe, to the tip of which a silk string guide has been tied, is now passed through the esophagus either from above or retrograde, as in the Abbe method. With this guide a loop of silk is drawn out of the gastric incision in such manner as to leave the guide as a third string. Into this loop a small soft-rubber drainage-tube three feet or more in length is caught in the middle by traction on the ends of the doubled thread through the mouth; this loop of rubber tube is drawn through the stomach and made to engage in the stricture.

"The greater the amount of traction, the smaller the stretched rubber tube, until it is sufficiently reduced in size to enter the stenosed portion; by alternating the direction of the pull the tube is drawn out by its free ends and in by the silk loop. Increasing sizes of tubes can be employed, and if necessary the third string can be used as a string-saw, after the Abbe plan of procedure." In a very severe case of stenosis gastrostomy is performed to keep the patient from starving. In a case of fibrous stenosis in charge of the author it was found impossible to insert any instrument from above or from below. Gastrostomy was performed by Kader's method. The patient was fed through the artificial opening and the esophagus was thus put at rest. Two weeks after the operation it became possible to pass a bougie from the mouth. The gullet was gradually dilated to its normal caliber and the gastrostomy wound was closed. This case demonstrates that a stricture of the esophagus, like a stricture of the urethra, may become temporarily impassable from inflammation, edema, and spasm; but, after the part is put at rest, will again permit the passage of an instrument.

Carcinoma of the Esophagus.—Cancer causes obstruction of the esophagus. It arises in those beyond middle life, and is far more common in men than in women. The disease may begin at any portion of the gullet, but is least often met with in the central portion (Maylard, Butlin). Epithelioma is the usual form, but scirrhus or encephaloid may occur. Cancer soon ulcerates, involves adjacent parts, and affects the deep cervical and posterior mediastinal glands.

Symptoms of Cancerous Stenosis.—The patient is over forty years of age, is usually a male, and presents the same difficulty of swallowing met with

* Jour. Amer. Med. Assoc., July 29, 1899.

in cicatricial stenosis. The vomited matter is apt to contain blood; the use of the bougie causes bleeding; there are generally decided pain and very great emaciation. The seat of obstruction is located by the bougie and by listening over the spine while the patient is attempting to swallow water. The stomach is the seat of pain; the mouth is dry, and there is often great thirst. As the disease infiltrates, the involvement of adjacent regions produces other symptoms. Dyspnea may result from tracheal pressure. Pleuritis, pericarditis, or pneumonia may arise.

Treatment.—The disease is of necessity fatal, and treatment is only palliative. Complete excision is scarcely feasible. The patient should be put upon a soft, bland diet, small quantities being given frequently. When trouble is experienced in swallowing the bland and soft food, pass a soft bougie every third or fourth day. When the patient becomes entirely unable to swallow soft food, we may insert a Symonds tube or do an esophagostomy (if this can be performed below the stricture), or perform gastrostomy. In every doubtful case of esophageal stricture give a course of iodid of potassium before performing any operation.

Spasmodic Stricture of the Esophagus (*Esophagismus; Hysterical Stricture*).—By this term is meant a spasm of the circular muscular fibers of the gullet, which is most common near the larynx or the cardia. This condition not unusually arises in a hysterical individual, in which case it will be associated with the stigmata of hysteria, especially globus hystericus. In some cases evidences of hysteria are wanting, although the patient is neurotic and ill-nourished, and the condition is due to a reflex irritation. A spasm of the muscular fibers of the esophagus may be clonic or may be tonic. A clonic spasm may arise during vomiting or from some reflex cause; it may affect one part of the tube for a time and then shift to another, or may develop only in one particular region. Globus is a spasm which moves upward. Tonic spasm is in one fixed place. Most reflex spasms are tonic and result from cancer of the liver, cancer of the stomach, tonsillitis, glossitis, pharyngitis, or inflammation of the epiglottis (A. L. Benedict, in "Am. Jour. Med. Sciences," August, 1904). Spasmodic stricture may also arise during pregnancy and as a result of laryngeal ulceration. I have seen two instances due to cancer of the stomach. In one of these cases the esophageal spasm entirely disappeared after the performance of pylorectomy. It occasionally occurs in tetanus, and sometimes in epilepsy.

Symptoms of Spasmodic Stenosis.—It arises suddenly in a hysterical or neurotic individual. It may last for a time and suddenly pass away, or may persist for a long time. The difficulty in swallowing is irregular, rarely interfering seriously with nourishment, and sometimes solids are taken more readily than fluids, and *vice versâ.*

There may be regurgitation; but if it occurs, it does so at once on swallowing food. Examination with a bougie detects the obstruction. If the bougie is held firmly against it, in most cases the spasm will, after a time, relax suddenly or gradually and let the instrument pass. A medium-sized instrument or a large instrument may not pass until the patient has been anesthetized, but in every case a bougie can be passed after an anesthetic has been given.

Treatment.—The systematic passage of bougies. Occasionally the passage of an instrument but once will cure a case. The general health must be

improved, and in persistent cases it may be necessary to use electricity within the esophagus, employ cold locally, and administer the bromids.

Diverticula of the Esophagus.—Maylard tells us that these pouches may be due to one of four causes—they may be congenital; may be due to stricture; may be caused by pressure from within, upon a weak spot of the wall; may be due to traction from without, by the healing and contraction of an area of inflammation. To these another cause should be added, muscular weakness resulting in dilatation.

Symptoms.—When the diverticulum is in the neck, a lump forms during deglutition, and this lump may be obliterated by pressure. Food will pass into the stomach only when the diverticulum is full. A bougie cannot be passed unless the pouch is full of food, at which time it may pass or may not. Sometimes it enters the pouch. This latter symptom, the variability in the passage of the bougie, is the evidence relied on for diagnosis in intro-thoracic diverticula. By listening with a stethoscope fluid may be heard to pass into the pouch. After a patient swallows food mixed with subnitrate of bismuth a diverticulum may be skiagraphed. The opening may be seen by means of an esophagoscope.

Treatment.—Extirpation and suture, as performed by von Bergmann, Hearn, and others. For five days after operation no food is given by the mouth.

Injuries of the Esophagus from Within.—Injuries of the internal surface are more common than injuries from without. Burns and scalds are among these injuries. Wounds may be inflicted by foreign bodies. Injuries of the gullet cause pain on swallowing, and a severe injury induces bleeding, the blood being both coughed up and vomited. A severe wound may involve a large vessel and cause violent or even fatal hemorrhage. If the bronchus or trachea is involved, there will be "cough and expectoration of blood, mucus, and food" (Maylard). The pleural or pericardiac sacs may be perforated.

Treatment.—Feed only by the rectum. Give morphin hypodermatically. Do not feed by the mouth for ten days, and even then give only fluid food and jelly. Symptoms are met as they arise. After burns by caustic, administer the antidote; give large drafts of water and wash out the stomach. From two to four weeks after a caustic has been swallowed and after a burn or scald the use of sounds should be begun, and sounding should be persisted in for a considerable time to prevent contraction.

Injuries of the Esophagus from Without, Other Structures not being Seriously Involved.—Such injuries are rare. Esophageal injuries, as a rule, are associated with serious damage to adjacent structures. These injuries may be due to stabs or to bullets. Besides the obvious external signs of the injury there will be difficulty in swallowing, cough, bloody expectoration, or vomiting; and mucus or the contents of the stomach may run out of the wound.

Treatment.—Suture the wound, and feed by the rectum for ten days.

Foreign Bodies Lodged in the Esophagus.—These accidents occur especially in children and lunatics, and women are more apt to suffer from them than are men. A list of various bodies which have been swallowed will be found in Poulet's elaborate treatise. There are three regions where a foreign body is especially apt to lodge—viz., opposite the cricoid cartilage,

at the level of the diaphragm, and at the point where the left bronchus crosses the gullet. Small and sharp bodies may lodge anywhere.

Symptoms.—The symptoms are variable; if the body is large, there will be pain and difficulty in swallowing, and, in some cases, dyspnea from pressure upon the trachea or bronchus. Occasionally the dyspnea is such a prominent feature that it misleads the physician into the belief that the foreign body is lodged in the air-passages. Death may actually result from asphyxia. In some other cases the symptoms are very slight. If the body is sharp, there will be hemorrhage and severe pain. The blood may be hawked up, or may be swallowed and vomited. A patient may grow accustomed to a foreign body and cease to notice it; but, on the contrary, the foreign body may produce inflammation, and may even ulcerate into the windpipe, the pleura, the pericardium, or the aorta. In many cases of impaction a patient makes violent efforts to hawk and produces aphonia. There may be violent retching. Even after a foreign body has been removed by swallowing or otherwise a sensation is apt to remain as if it were still lodged. The diagnosis is made by the history, the detection of the body by external manipulation, by feeling it with an esophageal bougie, and, if bone or metal, seeing it with the fluoroscope or obtaining a skiagraph.

Treatment.—The surgeon should learn, if possible, the size, shape, weight, and nature of the foreign body, and should locate its point of impaction. The exact point of lodgment of bone or a metallic body is determined by the *x*-rays.* An anesthetic is given before manipulating in a child, a nervous woman, or a lunatic, and is *sometimes* necessary for a man. If the foreign body is soft, external manipulation may succeed in altering its shape, so that it may be swallowed or ejected. If the foreign body is hard, external manipulation may shift its position. It is usually impossible to reach the foreign body through the mouth by means of the fingers (when the body is in the rear of the pharynx it may be pulled forward or pushed down). Sharp foreign bodies may be entangled and carried down when the patient eats mush, bread, or boiled potatoes. The administration of emetics is an old plan which occasionally succeeds, but which is too unsafe to be employed. Maylard says that when a mass of food is impacted it is occasionally possible to soften and disintegrate the mass by administering a mixture containing pepsin. The horsehair probang is a very useful instrument (Fig. 443, C). It may be used to push a body downward into the stomach, or to catch the body and pull it up. When this instrument is withdrawn, it opens like an umbrella. Maurice H. Richardson has shown that in an adult the diaphragmatic opening is about fourteen and one-half inches from the incisor teeth, a point to be remembered in deciding whether to push down or pull up the impacted article. Esophageal forceps (Fig. 443, A, B) are valuable in some cases. The coin-catcher (Fig. 443, D) is a useful instrument. Créquy's plan of removal is to take a tangled mass of threads, tie a stout piece of string about the middle of it, coat it with sugar, and have the patient swallow it. It may pass the foreign body; if it does so, on withdrawal it may entangle the object and extract it. To remove a fish-hook with line attached, the following plan may prove successful; stick the line which projects from the mouth into a metal catheter, carry the catheter down to the hook, and

* See cases of White, Keen, Alfred Wood, MacIntyre, Taylor, and others.

push the hook out. It is not proper to allow a foreign body to remain in the esophagus until it causes ulceration. Neither is it proper to make prolonged efforts to extract it through the mouth. Such efforts may do great harm, and if one careful and consistent effort fails, an operation should be performed. If the body is lodged anywhere above the lower third of the esophagus, external esophagotomy is performed, and usually on the left side. Through this wound the foreign body is extracted. The cut is made on the left side, between the trachea and larynx in front and the carotid sheath behind, the center of the incision being opposite the cricoid cartilage. After the foreign body is extracted the mucous membrane is sutured with chromicized catgut, and the superficial structures are closed with silkworm-gut after a drainage-tube has been inserted. The patient is fed by the rectum for eight or ten days. When a foreign body is lodged in the lower portion of the tube, the stomach is opened and the body extracted by this route (Richardson). In White's case of jackstone in the gullet gastrotomy was performed. A string was tied about some rolls of gauze, the string was passed by means of a whalebone from the stomach into the mouth, and the body was entangled and drawn out.

Surgical Invasion of the Mediastinum.—The posterior mediastinum has been entered in order to remove a foreign body from the bronchus and to extract a set of false teeth wedged in the esophagus. The same method can be followed to reach suppurative processes in the mediastinum, abscesses of the lung otherwise inaccessible, and diverticula of the lower end of the gullet (Enderlen, in "Deutsche Zeitschrift für Chirurgie," Nov., 1901). The anterior mediastinum may be entered to remove a bullet, to drain an abscess, to reach a wound of the heart or lung, and to explore for the cause of symptoms. I explored the anterior mediastinum after rib resection, found a bullet imbedded in the aorta, and allowed it to remain. The patient recovered. M H. Milton * splits the sternum and separates the two pieces.

* Lancet, March 27, 1897.

XXVII. DISEASES AND INJURIES OF THE ABDOMEN.

Diagnosis of Intra-abdominal Emergencies.—The exact diagnosis is always difficult and is not unusually impossible. What a surgeon must try to determine, and what he usually can determine, is whether he is dealing with a trivial and temporary derangement for the relief of which an operation is entirely unnecessary, or whether he is confronted with a grave calamity which imperatively demands immediate surgical aid. We can decide that a calamity exists, but the exact nature of the lesion is often doubtful until operation is performed. Every operation in such a case is exploratory. Before the diagnosis of a calamity is made morphin should not be given, because it allays the pain, relieves the anxiety, causes the disappearance of rigidity, lowers the pulse, abates shock, and hence veils the real situation, so that the most discerning surgeon will probably be misled. If shock is profound, diagnosis is usually impossible, unless shock is due to hemorrhage, and immediate operation during shock is not to be thought of except to arrest bleeding. If excessive and continued hemorrhage is suspected, immediate operation is indicated. If it is not suspected, the patient should be covered with blankets and surrounded with hot-water bags, atropin should be given hypodermatically, and hot salt solution should be administered by rectum, subcutaneously, or intravenously. Suprarenal extract is a valuable remedy to maintain blood-pressure in shock (Crile). When the patient reacts, and he usually will react, an attempt is made to make a diagnosis. It is perfectly proper to give a single hypodermatic injection of morphin (gr. $\frac{1}{3}$) after the effort has been made to diagnosticate the condition. The danger of deluding the surgeon is past and the drug abates pain, lessens peristalsis, relieves mental anxiety, and is distinctly beneficial. Before the morphin was given the surgeon came to a conclusion as to the necessity for operation. After the morphin has been given, if an operation is indicated, it is performed as promptly as circumstances admit. Whenever it is esteemed consistent with safety, the patient ought to be removed to a hospital for operation.

Contusion of the Abdominal Wall without Injury of Viscera.—In some cases of contusion of the abdominal wall only the parietes are damaged; in other cases the viscera or the abdominal tissues are injured. Contusion may involve the skin alone, or may involve the skin, muscles, and peritoneum. In *simple contusion* there is considerable shock if the injury is severe. There is pain, increased by respiration, motion, pressure, and attempts at urination or defecation. When tenderness appears some days after the accident there is usually deep-seated injury. Extensive ecchymosis may appear. Even after a severe contusing force has been applied there may be no discoloration, and it may happen that after a slight force there is much discoloration. There is great ecchymosis in anemic persons, victims of hemiplegia, in obese individuals, opium-eaters, and drunkards. In severe cases the tissues are pulpefied and sloughing inevitably ensues. Abscess occasionally follows contusion. The prognosis after abdominal contusion is always uncertain.

Treatment of Simple Contusion.—In treating simple contusion place the patient at rest in a supine position, with the thighs flexed over a pillow; obtain reaction from the shock. Give morphin if pain is severe. After shock has passed off it is advisable to place an ice-bag over the seat of injury. If much blood is extravasated into the abdominal wall, aspirate and apply a binder. After twenty-four hours apply local heat by means of the hot-water bag, employ an ointment of ichthyol, and move the bowels, if necessary, by salines. Regard every contusion as serious, and watch carefully for the development of signs of internal hemorrhage or visceral injury.

Muscular Rupture from Contusion.—In this injury there are severe shock and pain (increased by respiration and movement). Separation between the fibers of the muscle is distinct at first, but it is soon masked by effusion of blood. Such injuries may cause death, or may lead to hernia. The rectus is the muscle most apt to rupture. The rupture is due to sudden contraction rather than to the direct effect of a blow.

The *treatment* is the same as for simple contusion. Always apply a binder. A hernia is returned and a compress is applied over the opening through which it emerged. If strangulation occurs, operate at once.

Injuries with Damage to the Peritoneum or the Viscera.—Rupture of the Peritoneum.—The peritoneum may be involved in an abdominal contusion. It may rupture even when there is no visceral injury or muscular contusion. The uterine peritoneum, the parietal peritoneum, the visceral peritoneum, or the mesentery may rupture. Rupture of the peritoneum causes intra-abdominal hemorrhage.

The *treatment* consists in opening the abdomen, arresting the hemorrhage, and bringing about reaction.

An injury to the peritoneum creates a point of least resistance, and at such a point peritonitis may develop. The peritonitis is usually local, but may become general. After any severe intra-abdominal injury the symptoms of *peritoneal shock* appear (*peritonism*), and the patient may rapidly die. In the condition of peritonism the temperature is subnormal; the extremities are cold; the face is pallid and sunken; the pulse is small, weak, and very frequent; the respiration is shallow and sighing; there is great thirst; the patient is restless and turns uneasily, and there is rigidity and distention. Vomiting almost always occurs. In some cases there is regurgitation rather than vomiting. The abdomen is the seat of a violent, persistent pain. The patient is fearful of impending death. As the symptoms develop in a grave case they will point to one of two conditions—hemorrhage or peritonitis.

In *intra-abdominal hemorrhage* the subnormal temperature and other evidences of shock persist. Vomiting ceases, but nausea exists. The patient is uncontrollably restless and tosses about in bed. The thirst is great. The abdomen is rarely rigid. Fainting-spells occur. Blood-examination shows a marked fall in the percentage of hemoglobin. Percussion demonstrates the existence of an effusion which alters its position as the patient's position is altered, and which gradually increases in amount. Dulness is first met with in the loins. Digital examination of the rectum or vagina may aid in diagnosis because in hemorrhage blood gathers in the rectovesical pouch. If peritonitis develops, the vomiting becomes worse, the pain intensifies, and the abdomen grows rigid and distended.

Rupture of the Stomach without External Wound.—The usual cause of rupture is a violent blow, although the accident may happen while washing out the stomach. Rupture is more apt to occur when the stomach is distended with food than when it is empty. The rupture may be partial, the peritoneal coat not being torn. The rupture may be complete. Either the anterior or the posterior wall may suffer. The region of the pylorus is most apt to be lacerated. The symptoms of rupture are collapse, severe pain over the entire abdomen, great thirst, excessive tenderness, especially over the epigastric region, occasionally vomiting, the vomited matter being usually, but not invariably, bloody; tympanitic distention and muscular rigidity coming on after a few hours. Austin Flint pointed out years ago that gas may enter the abdominal cavity and cause the diminution or disappearance of liver-dulness, but the area of liver-dulness can be lessened by great intestinal distention, and I have seen cases of perforation of the stomach and intestine in which it was not lessened at all. After *incomplete* rupture local peritonitis is frequent; in *complete* rupture the escape of food into the peritoneal cavity causes general peritonitis. The contents of the stomach are not so liable to escape after rupture of that viscus as are the contents of the intestine after rupture of the gut, because of the thickness of the stomach-wall and the tendency of the mucous membrane to evert and block the opening. Perforations of the anterior wall are most apt to lead to extravasation and general peritonitis. Posterior laceration may cause subphrenic abscess. To diagnosticate between complete and incomplete rupture, Senn endeavors to distend the viscus with hydrogen gas; in incomplete rupture the contour of the dilated stomach can be made out upon the surface; in complete rupture the viscus cannot be distended, and the gas passes into the peritoneal cavity, producing the physical signs of tympanites. This maneuver is open to the objection that it may increase extravasation in a complete rupture.

The *treatment* for complete rupture is immediate operation. Treatment for shock is at once instituted and an intravenous infusion of salt solution is given before or during operation. In doubtful cases endeavor to bring about reaction and explore. Open the abdomen. Note if gas emerges from the wound or if stomach fluid appears. Search for the rupture in the same manner as we search for the opening of a perforated ulcer. When the rupture is discovered, flush out the stomach and the peritoneal cavity with hot salt solution; sew up the stomach-wound with a double row of silk sutures, the first row being buried and including the muscular coat and mucous coat, the second row being Halsted sutures; drain; close the wound in the parietes with silkworm-gut; place the patient in Fowler's position; let salt water at low pressure flow continuously into the rectum; feed by the rectum for four days, and then begin the administration of a very little food by the mouth. In incomplete rupture the danger is perforation. The patient is put to bed, and after reaction has taken place, is fed by the rectum for several days, and morphin is given hypodermatically. Cases of complete rupture not operated upon occasionally recover, adhesions arising and perigastric suppuration taking place. The mortality is extremely large. In 1896 Petry collected 23 cases in which operation was not performed. The mortality was 59 per cent. This mortality is not so large as one would anticipate. It is not impos-

sible that some of the cases were not positively instances of rupture. Nevertheless, the lesion, for reasons previously stated, is not nearly so dangerous as rupture of the intestine. Another reason for the greater danger of intestinal rupture is that fecal matter is much more poisonous than the gastric contents. Laparotomy has lessened the mortality of rupture of the stomach. Petry and also Eisendrath mass together operations for rupture of the stomach and rupture of the intestine. Petry finds the group mortality to be 52.3 per cent., and Eisendrath finds it to be 52.5 per cent. Statistics referring to the stomach alone should show a lower death-rate.

Rupture of the Intestine without External Wound.—In a great majority of cases the damage is produced by direct violence. In some few cases the force is indirect (falls on the feet or buttocks, blows on the back or loin). The injury may result from *oscillation* or from *compression* (the younger Senn). The common cause is undoubtedly compression of the gut against the pelvis or vertebral column, but it is certain that a gut containing fluid may be ruptured purely by violent shaking or oscillation. If oscillation produces the damage, the rupture is on the portion of gut furthest from the mesentery; if compression is the cause, any part of the bowel may suffer. Rupture is most apt to occur if the belly is relaxed. It is predisposed to by adhesions, disease of the wall of the bowel, and irreducible hernia (the younger Senn). Most ruptures are complete. In a very few cases the tear extends only through one or two of the coats and the rupture is incomplete. A contusion of the gut may be followed by rupture several days after the injury. A complete rupture usually permits leaking of feces, but in very rare cases a small opening is plugged up by pouting mucous membrane. Leaking may be delayed from a rupture because intra-abdominal pressure may for a time keep the opening pressed against a section of sound gut (the younger Senn). The amount of damage to the belly wall does not convey any notion of the amount of visceral injury. The belly wall may be severely injured and the viscera escape. With only a slight contusion of the wall there may be extensive visceral injury. Homer Gage * collected 85 cases; in 75 the injury was due to direct force, and in 32 of these the force was inflicted by the kick of a horse or of a man. In one of my cases it was due to the kick of a horse, in one to the kick of a man, and in one to a crush inflicted by a cart-wheel. The victims in the majority of reported cases were young men, probably because young men are most apt to be exposed to violence. In 78 collected cases (Gage) the situation of the injury was specified: The duodenum, 10; jejunum, 20; ileum, 42; large intestine, 6. Curtis found the large intestine injured in 4 cases out of 113, and Poland, in 5 cases out of 64. In many cases there is more than one tear, and sometimes many tears exist. Both the large and small intestines may suffer. Chavasse collected 106 cases in which the ileum or jejunum suffered, 19 in which the large intestine did, 7 in which the duodenum did, 7 in which both the large and small intestine were involved, and 1 case in which the rectum was ruptured (quoted by the younger Senn in "Am. Jour. Med. Sciences," June, 1904). As Makins points out, the portion of gut most apt to be injured is a portion hanging low in the pelvis, because a loop in this situation is most easily squeezed against bone by a blow on the belly. The mesentery may be lacerated (in 7 per

* Annals of Surgery, March, 1902.

cent. of cases, according to Gage; in 16 per cent., according to Curtis). The symptoms of rupture of the intestine are profound shock, tympanites, abdominal pain, and rigidity, rapidly followed by peritonitis if the patient survives. In some cases pain is referred to the back. Vomiting comes on soon after the accident, the vomited matters being possibly at first bloody and later stercoraceous. The respiration is thoracic, the tongue is dry, and great thirst exists. The pulse, which is slow at first, becomes small and rapid and of high tension. Blood in the stools rarely appears early enough to be of diagnostic value, and there may be diarrhea or constipation. The respiration is costal. Dyspnea exists. There may be no marked symptoms for an hour or two or for many hours. Cases are on record of people with ruptured intestine returning to work perhaps for hours. Holland's patient had no symptoms for twenty-four hours, although the jejunum was ruptured. Poland's patient ruptured the duodenum but walked one mile. The escape of gas into the peritoneal cavity may cause the diminution or disappearance of liver-dulness. After anesthetizing the patient, hydrogen gas insufflated into the rectum will come from the mouth if there is no perforation in the stomach or the intestine; if a perforation exists, tympanites is much increased, and the area of liver-dulness may disappear. To apply *rectal insufflation of hydrogen*, generate the gas in a bottle by means of zinc and sulphuric acid, catch the gas in a large rubber bag, and attach the tube from the gas reservoir to a tip which is inserted in the rectum. Give the patient ether to relax the abdominal muscles, direct an assistant to press the anal margins against the rectal tip, and when the patient is unconscious, turn on the stopcock and press upon the reservoir (the elder Senn).

It has been suggested that ether vapor, mixed with air, can be used instead of hydrogen gas.* In this method a little ether is poured into the bottle of an aspirator, the valves are opened, one tube is carried into the rectum, the other tube is attached to a bicycle pump, and by working the pump the ether vapor is driven into the bowel. If there is perforation, tympanites is notably increased. Most surgeons regard the rectal insufflation test as unsatisfactory and often dangerous. Personally I am not inclined to use it. Its application requires considerable time, it must of necessity increase fecal extravasation, and, as Le Conte† says, it "so distends the intestines that it may be impossible to return them to the abdominal cavity until they have been emptied of gas."

Treatment of Rupture of Intestine.—If symptoms point to dangerous hemorrhage, and in any case in which the patient does not seem to be reacting, but is rather getting worse, operate at once. If in doubt as to whether or not rupture exists, make every endeavor to bring about reaction, and explore. Reaction is brought about as previously directed. Asepticize and anesthetize. Perform a laparotomy, making the incision in the middle line and below the umbilicus; note if gas escapes when the peritoneum is opened or if fecal material or an inflammatory exudate flows out; check hemorrhage; start at a fixed point and conduct a careful search to find the rent. When the rent is found, it should be closed by Halsted sutures if possible. It is only a small rupture, however, which can be so treated. Most large tears

* Emerson M. Sutton, of Geneva, in Jour. Am. Med. Assoc., July 23, 1898.

† Am. Jour. Med. Sciences, Dec., 1901.

make resection necessary. Because of the frequency of multiple lesions the surgeon must not be sure he has finished his work when he finds and closes one tear, but he must determine by careful search that no other tears exist. The surgeon notes if there is injury of the mesentery and if the circulation of any portion of the bowel is interfered with. If there is serious impairment of circulation in any part of the bowel-wall, perform intestinal resection, followed by end-to-end approximation or lateral anastomosis. In some cases of rupture the patient is so severely shocked that it is impossible to do a resection with any hope of the patient living. In such a case stitch the ruptured portion of gut to the belly-wall. The opening in the gut becomes a fecal fistula, and if the patient survives, can be subsequently closed (Senn). The same procedure is proper if the bowel is distended and paralyzed. After closing the opening in the bowel or resecting flush the abdominal cavity with hot saline solution, and wipe the peritoneal fossæ and the space between the liver and diaphragm with gauze. Finney eviscerates, wipes out the abdominal cavity, and wipes the intestines as he restores them. This is justifiable if the operation is done soon after the rupture, but not in later cases, in which lymph has gathered on the bowel. Whatever method is used to cleanse the abdomen, remember that infectious material is apt to accumulate between the liver and diaphragm and in Douglas's pouch. Drainage is to be used. Suprapubic drainage is most advantageous. Place the patient semierect and employ continuous proctolysis of normal salt solution as directed for peritonitis. The value of operation for intestinal rupture is conclusively demonstrated. Curtis collected 116 cases which occurred before 1887. Not a case was operated upon, and every patient died. Homer Gage collected 85 cases since 1887: 45 were not operated upon and every one died; 40 were operated upon and 17 recovered. Eisendrath collected 40 cases operated upon. Nineteen recovered and 21 died (52.5 per cent.). The mortality of cases not operated upon is, according to Eisendrath, at least 93 per cent. The sooner after the injury operation is performed the greater the chance for success. The younger Senn points out that in operations done within four hours the mortality is 15.2 per cent.; in those done between five and eight hours it is 44.4 per cent.; in those done between nine and twelve hours it is 63.6 per cent., and in those done later it is 70 per cent.

Identification of the Small Intestine and of the Large Intestine.—"In abdominal operations it is frequently imperatively necessary that the large intestine be recognized with certainty or the small bowel be positively identified. The size of the tube will not always aid in this recognition, as a small intestine may be distended enormously and a large intestine may be contracted to the size of a finger because of obstruction above. The longitudinal muscular fibers of the large bowel are accentuated in three portions; these accentuations constitute the three longitudinal bands which begin at the cecum and terminate at the end of the sigmoid flexure of the colon. Each band is composed of a number of shorter bands, the shortness of these constituent bands permitting the sacculation of the large intestine. Longitudinal bands and sacculation are not met with in the small gut, their presence or absence being a means of identification in many cases; but when the colon is much distended, the bands cannot be seen distinctly and the sacculation disappears. From the large intestine only spring the appendices

epiploicæ (small overgrowths of fat in pouches of peritoneum), but they are sometimes not well marked except upon the transverse colon, and when emaciation exists they may almost entirely disappear. The relatively fixed position of the large intestine and the free mobility of the small bowel are important points of distinction. The foregoing indicates that it is not always easy to distinguish between colon and small gut, and that, according to old rules, it may be often necessary to make large incisions, to see as well as feel, and to handle a large extent of the bowel. Any scrap of knowledge that will shorten an abdominal operation, that will permit of as certain work through a smaller incision, and that will diminish handling of intraperitoneal structures, tends to increase the chances of recovery. For these reasons the writer suggests a method of bowel-identification which rests upon the facts that each bowel has a posterior attachment, that the origin of the attachment differs according to the bowel it supports, that a single finger can detect the origin of the peritoneal support of any section of the bowel, and, this origin being known, the portion of the bowel it supports is with certainty deducible. In an exploratory operation, for instance, the finger comes in contact with the bowel: to determine whether it is a large or a small bowel, note first if the structure is movable or is firmly fixed; next, pass the finger over the bowel and let it find its way posteriorly. If dealing with a small bowel, the finger will reach the origin of the mesentery between the left side of the second lumbar vertebra and the right sacro-iliac joint; if dealing with the large bowel, the finger will reach the origin of the mesocolon, or the point where the colon is fixed posteriorly and to the side."*

Location of a Loop of Small Intestine (Figs. 446, 447, 448, and 449).—Monks points out a plan by which, in most instances, we can learn with approximate accuracy what portion of the small intestine we may have hold of ("Annals of Surg.," Oct., 1903). He learns first by observation of the mesenteric vessels. Opposite the upper portion of the bowel there are primary vascular loops only with perhaps an occasional small secondary loop. As we descend, "secondary loops become more numerous, larger, and approach nearer to the bowel than the primary loops in the upper part," and about the fourth foot these secondary loops first become a "prominent feature." As we descend, primary loops become smaller, secondary loops become more numerous, and nearer the bowel, and possibly tertiary loops appear. Opposite the lower portion of the ileum the loops are not definite in arrangement, but are simply a network. Monks points out that opposite the upper bowel the vasa recta, when put gently on the stretch, "are straight, large, and regular, and rarely give off branches to the mesentery," and are about 5 cm. long. In the lower one-third they are usually less than 1 cm. long, are smaller, are not quite so straight, are not so regular, and give off numerous mesenteric branches. Monks further shows that fat impairs the translucency of the mesentery. The thinnest mesentery is that connected with the upper gut. As we descend the mesentery becomes thicker and thicker, because of fibrous tissue, unstriated muscle, and fat. Translucency varies greatly. If a loop of upper intestine is raised against the light, one notices close to the gut and between the vasa recta transparent lunettes. The lunettes become smaller and fatty as we descend, and disappear at the eighth foot. In an incision in the median line, if the loop of

* The author, in Medical News, June 9, 1894.

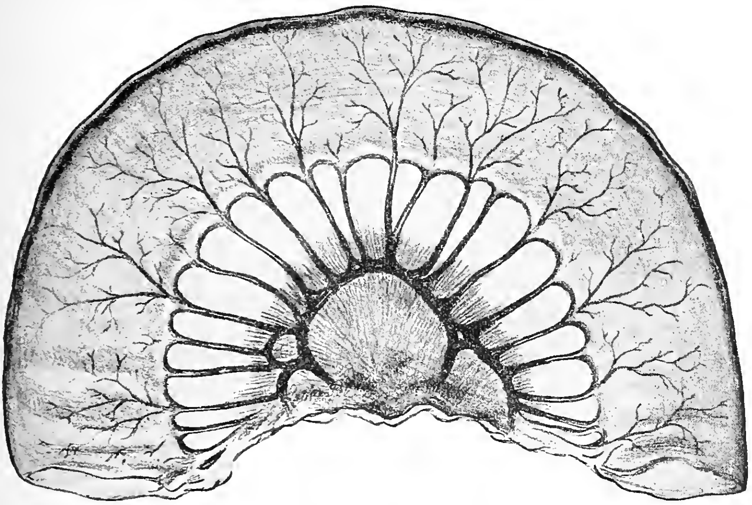


Fig. 446.—A loop of intestine, the middle of which is exactly three feet from the end of the duodenum. The gut is of large size. The mesenteric loops are primary, and the vasa recta large, long, and regular in distribution. The translucent spaces (lunettes) between the vessels are extensive. Below, the mesentery is streaked with fat. The veins, which had a distribution similar to the arteries, are for simplicity omitted from this and from the subsequent drawings. The subject from which the specimen was taken was a male of forty years, with rather less than the usual amount of fat. The entire length of the intestine was twenty-three feet (Monks).

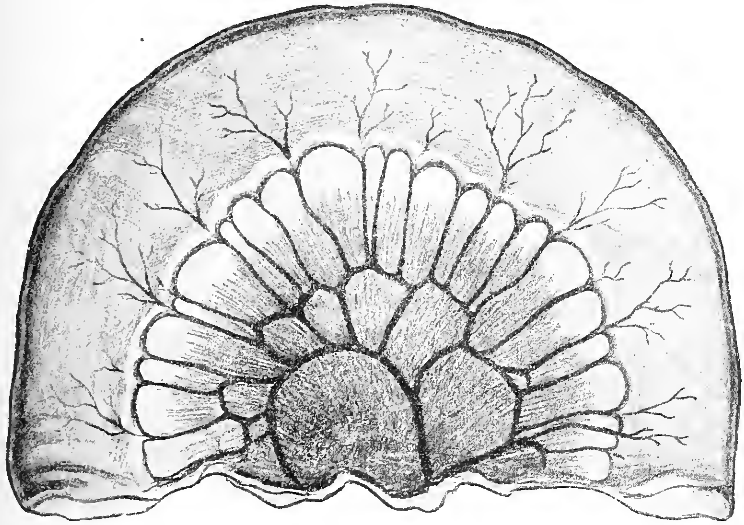


Fig. 447.—A loop of intestine at six feet. As compared with Fig. 446 the gut is somewhat smaller. The vascularity of the intestine and mesentery is less. Secondary loops are a prominent feature. The vasa recta are smaller. The lunettes are also present, but are not so large as in Fig. 446. The subject was a male of about thirty-five years, with an average amount of fat. The entire length of the intestine was twenty feet (Monks).

intestine is pulled downward we can determine if "the line of resistance from above is from the median line of the body or from the left or right of it."

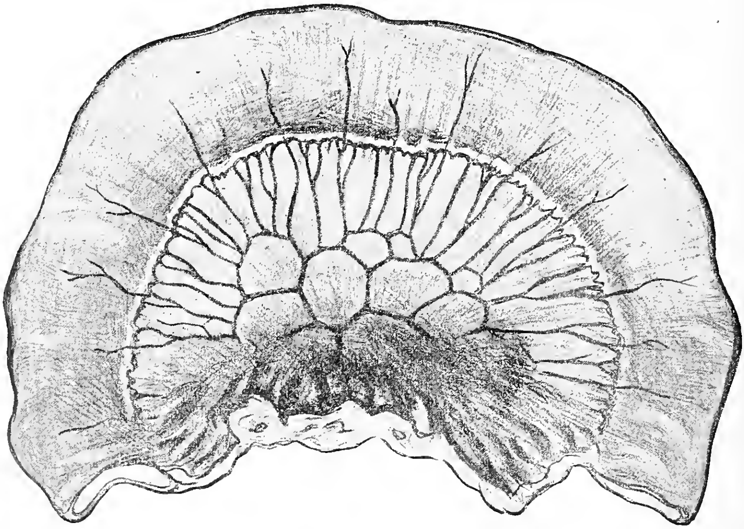


Fig. 448.—A loop of intestine at twelve feet. The vessels are smaller. The primary loops are lost in the fat, but secondary and even tertiary loops are visible. The vasa recta are shorter, more irregular, and branching. The specimen came from the same subject which furnished Figs. 446 and 447 (Monks).

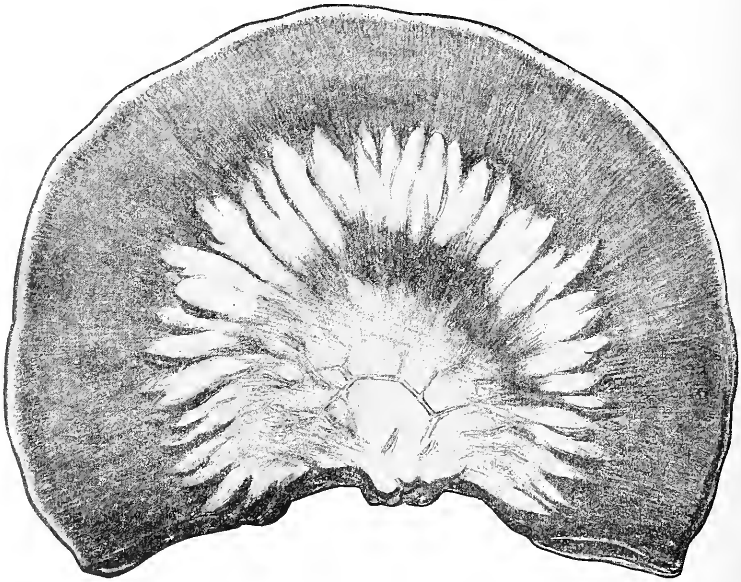


Fig. 449.—A loop of intestine at twenty feet. The gut appears to be thick and large. The mesentery is quite fat and opaque, and large and numerous fat tabs are present. The vessels, which are complicated, are seen with difficulty, and are represented by mere grooves in the fat. The subject was a stout woman, and the entire length of the gut was twenty-one feet (Monks).

This resistance of the mesentery indicates to which point the loop is attached, and hence what portion of bowel the loop comprises. I have used these observations of Monks repeatedly to great advantage.

Rupture of the liver (page 875).

Rupture of the Gall-bladder and the Bile-ducts (page 875).—Rupture of the gall-bladder or the ducts is most apt to happen from injury when gall-stones exist. Peritonitis, general or local, is almost certain to follow such a rupture. Besides those symptoms common to all severe abdominal injuries, there is often intense jaundice.

Treatment.—Suture the laceration or make a biliary fistula.

Rupture of the Spleen (page 902).

Rupture of Mesentery Arteries.—The symptoms are those of hemorrhage. Aldrich* reported a case in which death occurred on the seventh day.

Rupture of the Kidney (page 1107).

Rupture of the Ureter (page 1109).

Wounds of the Abdominal Wall.—**Non-penetrating wounds** are to be treated on general principles. They are sutured with great care and are firmly supported externally. Ventral hernia may follow a large wound.

Penetrating Wounds.—The *symptoms* of penetrating wounds of the abdominal wall are usually those of shock and hemorrhage, and later of septic peritonitis. Emphysema is apt to occur and viscera may protrude, and often do in the case of a large incised or lacerated wound. Extravasation of contents of intra-abdominal viscera is very apt to occur, and is sure to occur if the viscus was distended when injured. Normal urine and normal bile may do little harm, but if either excretion is septic, disastrous consequences are certain to ensue. If intestinal contents escape, septic peritonitis is certain to occur. Bleeding is usually profuse and prolonged, because spontaneous arrest of hemorrhage from any vessel of considerable size will rarely take place within the abdomen.

Treatment.—The surgeon endeavors to discover promptly if a wound of the abdominal wall is or is not penetrating in character. This fact may be proved by protrusion of viscera, by the appearance of stomach-contents in the wound, or by a flow of bile, urine, or feces from the wound. If none of the above indications exists, and if there are no signs of serious hemorrhage, the wound should be irrigated with hot salt solution, and should be dressed with gauze, and every effort should be made to bring about reaction; otherwise operation should be immediate.

When reaction is obtained, the wound should be enlarged layer by layer until it becomes obvious whether or not the peritoneum is open. Madelung, of Strassburg, points out that incision layer by layer will be of no use in settling the question of penetration if the wound is in the chest, the buttock, the perineum, or the back of a fat individual.† If after incision layer by layer it becomes evident that penetration has not occurred, the wound should be closed and treated on general principles. If it becomes evident that it has occurred, the abdomen should be opened at the point of penetration, and a thorough exploration of intra-abdominal structures should be made in order to determine injury and be able to treat it properly.

In a case still doubtful after incision layer by layer, do an exploratory

* Annals of Surgery, March, 1902. † Annals of Surgery, Sept., 1897.

laparotomy in the middle line. It is impossible to affirm from the appearance of the wound and from the symptoms that visceral injury has not occurred; hence in every penetrating wound in civil practice perform exploratory laparotomy.

In every case in which it is evident that penetration has occurred laparotomy is necessary in order to detect and correct intra-abdominal injury, and clean the peritoneum by flushing with hot salt solution. If viscera protrude, they must be washed off with hot salt solution and covered with hot sterile pads, and after the patient has reacted, the wound should be enlarged, the condition of the contents of the abdomen investigated, hemorrhage arrested, wounds properly treated, and the viscera returned.

It is customary to flush the belly with hot salt solution, some of the fluid being allowed to remain. This proceeding mechanically cleanses the peritoneum, removes blood-clots, and strongly combats shock. It is not absolutely necessary to flush out the belly unless a considerable hemorrhage has occurred or feces or stomach-contents have been extravasated. If extravasation of stomach-contents or feces has occurred, not only should flushing be practised, but evisceration should be carried out; the fouled intestine should be wiped off with gauze pads wet with hot salt solution, and be wrapped in hot moist towels; the peritoneal fossæ should be rubbed with gauze pads and the space between the liver and diaphragm should be carefully wiped.

A wound of the stomach should be sutured; a wound of the bowel may be sutured, or resection and anastomosis or resection and end-to-end suturing may be required. Visceral injuries are treated by appropriate means. In a punctured wound or a gunshot-wound of the intestine rectal insufflation of hydrogen gas when the abdomen is open may disclose the situation of the injury, but evisceration is usually practised instead.

After the completion of intra-abdominal manipulations the surgeon restores any protruding bowel.

Drainage is required when the contents of the stomach or the intestines have escaped, when hemorrhage is severe, or when the liver, pancreas, kidney, or spleen is found to be damaged. The peritoneum may be sutured with a continuous suture of catgut, and the muscles, fascia, and skin with interrupted sutures of silkworm-gut, or through-and-through sutures of silkworm-gut may be used. Active stimulation and artificial heat are needed immediately after the operation to combat shock. In many cases intravenous infusion of hot normal salt solution is of great value. It may be given both during and after operation. Enteroclysis, or high rectal injection of hot saline fluid, is useful. So is hypodermoclysis, or the subcutaneous injection of hot salt solution. The after-treatment consists of the semierect position, continuous proctolysis of salt solution, avoidance of food by the stomach for forty-eight hours, and the administration of brandy and water from time to time. For two days the patient should be fed by the rectum. On the appearance of the first sign of peritonitis, forty-eight hours or more after the operation, give a saline cathartic. It is not wise to purge during the first forty-eight hours after the operation, unless a Murphy button was used. When there is no sign of peritonitis, a purge should not be given until the fourth day. After forty-eight hours liquid food can usually be given by the stomach. Solid food may be given after seven or eight days, but the patient must not leave his bed until the wound is firmly united, because of the danger of ventral hernia. A support should be worn for a long time.

E. D. Fenner* reports 39 stab wounds of the abdomen operated upon in the Charity Hospital of New Orleans. There were 9 deaths (23.07 per cent.).

Gunshot-wounds of the Abdomen.—The bullet may penetrate from the front, the side, the back, the chest, or the perineum. If a bullet has penetrated, it may or it may not have produced visceral damage. A pistol-bullet or the bullet of a sporting-rifle usually does; a projectile of a modern military rifle may not or may produce wounds which can be recovered from without operation. A urinary examination should be made promptly to see if blood is present.

In gunshot-wounds of the belly shock is usually due to hemorrhage, and in civil practice certainly prompt operation is indicated. The incision is made through the belly even when the shot entered the back. In some cases the opening is made through the wound; in others it is not; but in every case the wound is explored and cleaned. The incision should be long enough to permit of thorough work. After opening the abdomen our first duty is to arrest hemorrhage, our next is to look for perforations of the viscera and mesentery and close them. If the anterior wall of the stomach is perforated, close the opening and examine the posterior wall through an opening made in the gastrocolic omentum. If a posterior perforation is found, close it and insert posterior drainage into the lesser peritoneal cavity. As a rule, an intestinal perforation can be closed, but occasionally a portion of the intestine requires resection. If the bullet is encountered it is removed, but a prolonged search for it should never be made. Finally the abdominal cavity is cleansed, drainage is provided for, and the abdominal wound is closed. In one of my fatal cases the bullet entered the rectum low down and was not found. In a case of mine with 6 perforations of the small intestine recovery followed operation.

E. D. Fenner † reports 113 gunshot-wounds of the abdomen operated upon in the Charity Hospital of New Orleans; there were 78 deaths (69 per cent.). In a series of 14 cases operated upon by Vaughan the mortality was 64 per cent. ("Am. Jour. Med. Sciences," Feb., 1906).

Military surgeons have shown that wounds inflicted by the modern hard-jacketed projectile are not so apt to involve fatal hemorrhage and disastrous complications; in fact, such wounds are often recovered from without operation, and sometimes with an entire absence of serious symptoms. Again, it is difficult or impossible to treat such cases as in civil practice, even were it desirable. In fact, in military practice the results are slightly better from expectant treatment, whereas in civil practice the reverse is true. Still, even in war, if conditions permit, operation should be performed if there is hemorrhage or obvious visceral injury, or if septic peritonitis develops. Treves says that in the Boer War only 40 per cent. of cases of gunshot-wounds of the abdomen not operated upon died, but, as pointed out by Hildebrandt, many cases die on the battle-field and while being taken to the hospital, hence the mortality is much higher. In the war between China and Japan the mortality from gunshot-wounds of the abdomen is said to have been about 77 per cent.

Gunshot-wounds of the Pregnant Uterus.—It is rarely that both walls are perforated, as the force of the bullet is greatly lessened by the uterine contents. As a rule, there are severe shock and hemorrhage, and occasionally amniotic fluid flows from the wound of entrance. The intestine may also be

* Annals of Surgery, Jan., 1902.

† Annals of Surgery, Jan., 1902.

injured. As a rule, labor pains come on soon after the injury. Gellhorn* has collected 18 cases. In this series there were 12 recoveries. The proper treatment early in pregnancy, if the wound is small, consists in emptying the uterus and closing the wound. A large wound, or any wound late in pregnancy, demands the Porro operation.

Stomach and Intestinès.

Foreign Bodies in the Stomach and Intestine.—Foreign bodies of considerable size are rarely taken into the alimentary canal except by children, insane people, or drunkards. Small bodies (bits of straw, fragments of bone, etc.) are frequently swallowed. Most foreign bodies swallowed are passed with the feces, but some lodge. Any body which can pass the esophagus is not too large to pass through the intestines. Lodgment is an accident, not an inevitable consequence—an accident which is due to the shape and size of the body. A foreign body may lodge in the stomach. In some cases there are no symptoms. In other cases symptoms are violent. The severity of the symptoms depends upon the shape and character of the body.

In some cases it is possible to feel the body from without. A metal body in the stomach will deflect a magnetic needle held over the viscus (Polaillon). Many foreign bodies can be skiagraphed. A body of small size may pass through the entire canal but may cause perforation. If perforation occurs, the foreign body may become encysted, for instance, in the mesentery; may cause an abscess or may cause general peritonitis. A fish-bone may cause an anal abscess. An epiploic appendix may cause sacculation of the bowel, perforation may take place in this sac, an *epiploic abscess* resulting, which may attain considerable size and may be mistaken for carcinoma (J. Bland Sutton, in "Lancet," Oct. 24, 1903). It is not wise to attempt to recover a foreign body from the stomach by inducing vomiting. In some cases gastrotomy is necessary. When a small or sharp foreign body has been swallowed and has not caused perforation, abscess, or obstruction, the usual treatment is as follows: a purgative should *never* be given to expedite the passage of a foreign body, because increased peristalsis means increased danger of impaction or of perforation. Endeavor to encrust the foreign body, and thus lessen the danger of perforation, by feeding with bread and milk only for several days, and at the end of this period give a mild laxative. An exclusive diet of mush or of mashed potatoes has been suggested. Suet dumplings may be given. Pain is relieved by opium. A foreign body rarely lodges in the duodenum, but may lodge lower down, and may cause ulceration, perforation, abscess, or intestinal obstruction. Operation is necessary in such cases.

Volvulus of the Stomach.—This condition is very unusual. Ten cases are on record (Streit, in "Am. Jour. Med. Sciences," June, 1906). The symptoms come on suddenly with abdominal pain, distention, vomiting, and collapse. The rotation of the stomach may be on its vertical or on its longitudinal axis. An hour-glass stomach may undergo twisting on its vertical or longitudinal axis. Berg operated successfully for volvulus of the stomach. He opened the abdomen, relieved distention by tapping the stomach with a trocar, and then easily corrected the twist.

*St. Louis Med. Review, Dec. 2 and 9, 1901.

Carcinoma of the Stomach.—Innocent tumors and sarcomata occasionally attack the stomach, but they are infinitely rare in comparison with primary cancer. This disease is unusual before the age of forty, and is practically never seen before the age of thirty. It is more common in men than in women, the proportion being as 5 to 4. In a very few instances cancer has been found to have arisen from an ulcer. The forms of cancer met with, set forth in their order of frequency, are, according to Osler, epithelioma, encephaloid, scirrhus, and colloid. Cancer may be limited to the body of the stomach (either curvature or either wall), the pyloric end, or the cardiac end; but it may involve two of these regions, or almost the entire stomach, or, being multiple, may be found in many parts. It is usually fatal in from four months to two years, and most patients die within one year. In 60 per cent. of cases the pylorus is involved. In over half of the cases of cancer of the pylorus there is no important lymphatic involvement (McArdle). In investigating any gastric disorder follow Mayo's advice and study the history, the size and situation of the stomach, determine the existence and situation of pain and tenderness, the presence of a tumor, and if the passage of food is interfered with.

Symptoms.—Examine with care a patient in whom cancer is suspected. In unusual cases it produces no symptoms until it has lasted for some time and has attained a large size. In nearly all cases it does produce symptoms. The disease comes on gradually, usually with indigestion and physical weakness. The patient has persistent dragging pain, which is increased by eating and pressure, and attacks of vomiting are frequent. After a short time the patient becomes very weak and exceedingly anemic, and it is often possible to feel a tumor in the stomach. Blood examination shows diminution of red corpuscles and hemoglobin and absence of any increase of leukocytes after a full meal. The vomiting of gastric cancer is at first only occasional, but as the case progresses it becomes more and more frequent. Vomiting soon after eating occurs when the cardiac region is involved; vomiting an hour or so after eating occurs when the pyloric end is involved. When the body of the organ is the seat of disease, vomiting may be absent. The vomited matter is often mixed with a small amount of altered blood (*coffee-ground vomit*). A *test-meal* is given and important conclusions are sometimes derived from the presence or absence of hydrochloric acid and lactic acid. It is my custom to have the stomach washed out and then have Ewald's test-breakfast given. This consists of one roll of white bread (35 gm.), 400 gm. of H_2O, and 400 gm. of tea without milk or sugar. In one hour the stomach is emptied by means of a tube and a pump or a tube and abdominal compression, and the material is examined. If the result of the test seems out of accord with the other symptoms, repeat the process (L. Boas, in "Berlin. klin. Woch.," No. 440, 1905). In most cases free hydrochloric acid is not found in the stomach-contents, but lactic acid is found and Oppler's bacillus can often be detected. There may be red blood-corpuscles in the fluid. If the cancer is not ulcerated, free hydrochloric acid will probably be found; if it is ulcerated, it will usually be absent.* Free hydrochloric acid may be absent from the stomach because of atrophy of glands, cessation of secretion, or neutralization by the products of the cancerous area. Free hydrochloric acid may be absent when cancer

* Reissner, in München. med. Woch., Dec. 3, 1901.

does not exist. I have noted its absence in two cases of cicatricial stenosis of the pylorus.

It may be absent in cancer of the esophagus, advanced Bright's disease, cancer of the duodenum, febrile conditions, and amyloid disease. The constant presence of considerable quantities of hydrochloric acid is strong evidence against the existence of cancer of the stomach. If cancer arises from ulcer, free hydrochloric acid is apt to be present for a considerable time.

Distend the stomach with gas or fluid and map out its outlines. Feel for a tumor. A tumor can usually be felt if it involves the greater curvature or anterior wall, and a large tumor of the pylorus can be palpated, but in other regions the tumor can rarely be felt.

Cancer of the cardiac end interferes with the entrance of food into the stomach, and in such a case the stomach is shrunken and the esophagus is dilated immediately above the growth. In cancer of the pylorus the food is partially or completely arrested as it passes to emerge from the stomach, and the stomach becomes much dilated. The vomited matter in a case of cancer rarely contains recognizable fragments of the growth, but fluid with which the stomach has been irrigated may contain pieces which can be identified as cancer (Rosenbach).

In cancer of the stomach the general course of the temperature is normal, but there are occasional deviations to below or above normal. In many cases the urine contains albumin, indican, acetone, and casts. Occasionally cancer of the stomach produces spasm of the esophagus. I have seen this in two cases. Cancer of the stomach is apt to involve secondarily adjacent lymph-glands, or organs or other structures, especially the liver; in fact, the liver is involved in 30 per cent. of the cases (Welch). Occasionally there is enlargement of the supraclavicular glands of the left side. Metastases are usual and early, but in cancer of the pylorus 60 per cent. of the cases show no distinct lymphatic involvement. In many doubtful cases exploratory incision is justifiable.

Treatment.—The *medical* treatment consists in milk-diet and the use of morphin and of *lavage* if the pylorus or body of the stomach is diseased. Perform lavage as follows: The tube for lavage should be long enough to extend about three feet out of the mouth when the other end is in the stomach, it should be flexible, should have an opening in the stomach-end and another opening on the side about one inch above the stomach-end. The tube should be greased with glycerin. The patient sits down, throws the head back, opens the mouth widely, and is directed to take deep breaths at regular intervals. The tube is carried into the pharynx, the patient is ordered to make efforts to swallow it, and the tube is thus taken into the stomach. About one quart of fluid is poured into the funnel-like end of the tube, and just before the tube empties itself of the last of the water the funnel is lowered and the fluid runs out. This proceeding is repeated till the fluid becomes clear. The best fluid to use is a solution of bicarbonate of sodium, a teaspoonful of the salt to a quart of warm water. Lavage should be practised before breakfast, and sometimes also at bed-time.

The *indications for operation* are well set forth by Macdonald:*They are progressive aggravation of symptoms in spite of a rigid diet and medical

* John B. Murphy, in Chicago Med. Recorder, June 15, 1902.

treatment, loss of gastric mobility, progressive diminution of gastric peristalsis, progressive diminution of free hydrochloric acid, emaciation even under forced feeding, progressive reduction of hemoglobin to 65 per cent. or under, and moderate leukocytosis.

Surgical treatment aims to remove the growth or to obviate the effect of obstruction at one of the orifices of the stomach.

In cancer of the body of the stomach, if the growth is not extensive, excision may be performed; if it is extensive, it is useless to attempt it unless the growth is absolutely non-adherent. Schlatter, of Zürich; Brigham, of San Francisco; Richardson, of Boston; Macdonald, of San Francisco; Boeckel, of France; and De Carvalho, of Brazil, and others have successfully removed the entire stomach and attached the esophagus to the small intestine (*complete gastrectomy*). In these cases digestion was satisfactorily performed after removal of the stomach. Very rarely will cases be found suitable for such a radical proceeding. The case suitable for this treatment is one in which the entire stomach is involved in the growth, in which there is no obvious glandular involvement, and in which the stomach is not adherent but is freely movable. In limited cancer of the body of the stomach perform *partial gastrectomy*. In cancer of the cardiac orifice of the stomach the surgeon usually keeps the passage open as long as possible by the frequent passage of a tube, and through this tube introduces liquid food. Sometimes a small tube is introduced and permanently retained. When it becomes difficult to introduce a tube, *gastrostomy* may be performed. As a matter of fact, in most cases gastrostomy is done as a last resort, and it is scarcely worth doing in cancer of the cardiac end of the stomach. It is far more useful in cancer of the esophagus. In cancer of the pylorus, limited in extent and without lymphatic involvement, *pylorectomy* may be performed; but in cancer which has widely infiltrated the coats of the stomach and has involved the lymphatic glands *gastro-enterostomy* is performed as a palliative measure, the patient during the rest of his life subsisting upon liquid or semiliquid foods and submitting to frequent irrigation of the stomach to remove food-residue. In cases of irremovable cancer it is usually best to create the opium-habit.

The most successful of all the above operations are pylorectomy and partial gastrectomy. There are in literature 43 cases which have survived three years or over (Macdonald). Mayo reported 21 gastro-enterostomies for cancer with 4 deaths. The greatest prolongation of life was nineteen months. His experience makes him question if the operation is worth doing in malignant disease.

Sarcoma of the Stomach.—Of recent years it has been proved that sarcoma is more common than was once supposed. There are over 60 cases on record. It can occur at any age, but is more usual in early life than is carcinoma. It has been estimated by Wm. T. Howard * that 37.7 per cent. of cases are under the age of forty, and 11.44 per cent. are under the age of twenty. The pylorus is involved in about one-fourth of the cases. In most cases the posterior wall and greater curvature are involved. Howard says there is a diffuse growth in 21.31 per cent. of cases and that the cardiac end is involved in only 4.9 per cent. of cases. Sarcoma arises in the submucous coat. Any form of sarcoma may arise. It causes stenosis in less than one-tenth of the cases. There is no sex predisposition in sarcoma, as there is in cancer.

* Jour. Am. Med. Assoc., Feb. 8, 1902.

Symptoms.—A tumor forms, grows rapidly, and often attains a large size, and not unusually actually causes a projection of the abdominal wall. If it ulcerates, there will be hematemesis, but it often does not ulcerate, and bleeding is much rarer than in carcinoma. Not unusually this growth arises in a person under forty, and sometimes in one of less than twenty years of age. Stenosis is uncommon. The liver is involved secondarily in only 11.47 per cent. of cases (Howard), metastases are more rare than in carcinoma, free hydrochloric acid is usually absent from the gastric contents, and microscopic examination of washings from the stomach may detect fragments of sarcoma. Certain diagnosis is impossible without exploratory incision. Howard estimates the average duration of life to be from nine to ten months.

Treatment.—If the liver is free and if there are no metastases, partial gastrectomy or complete gastrectomy may be advisable. If there is pyloric stenosis, gastro-enterostomy may be performed.

Ulcer of the Stomach.—Ulcer of the stomach is a condition due to digestion of a portion of the stomach-wall by very acid gastric juice, the destroyed portion having been the seat of lowered vitality. The reason for the lowered vitality of the gastric mucous membrane is uncertain. Thrombosis has been suggested as a cause, but it is rare in gastric ulcer. Embolism is assigned by some as a cause, but emboli are seldom found on pathologic examination. Some observers blame infection; some, direct damage to the mucous membrane, but the question is involved in uncertainty. What does seem to be certain is that anemia strongly predisposes to the formation of very acid gastric juice (*hyperchlorhydria*) and to ulceration.

Ulcers are far more common in females than in males, and are more frequent in young women than in those of middle or advanced age. Men about forty and women between twenty and thirty are particularly liable. There is usually a single ulcer, but in one-fifth of all cases there are two or more, and when there is an ulcer on the anterior wall, it is not uncommon to find one exactly opposite on the posterior wall (Rodman). The Mayos divide ulcers into two clinical forms, the *indurated* and the *non-indurated.* In the indurated ulcer all the coats of the stomach are involved and the mass of scar tissue indicates an effort at repair. The most common situation for this form of ulcer is the region of the pylorus (Wm. J. Mayo, in "Jour. Am. Med. Assoc.," Oct. 21, 1905). The non-indurated ulcer involves the mucous coat only and may be of microscopic size, and even a microscopic ulcer may cause death from hemorrhage (Wm. J. Mayo). These non-indurated ulcers exhibit no sign, or almost no sign, on the outer surface of the stomach, and may not be detected even when the stomach in opened by the surgeon. The non-indurated ulcers are divided into the *mucous erosions* of Dieulafoy, in which the superficial epithelium only is involved, and the true round fissured *peptic ulcers* (Wm. J. Mayo, "Jour. Am. Med. Assoc.," Oct. 21, 1905). Ulcers are also divided into *acute ulcers*, which progress rapidly and produce definite symptoms, and *chronic ulcers*, which are usually chronic from the beginning, but which may exhibit acute exacerbations, and may have periods of great relief or apparent cure (Wm. J. Mayo, in "Med. Record," August 6, 1904). The most common seats of ulcers are the posterior wall and lesser curvature, especially in the pyloric region—in fact, 80 per cent. occur in the pyloric region (Rodman). An ulcer may heal or may perforate. Only

2 per cent. of ulcers on the posterior wall perforate, as they tend to form adhesions to adjacent structures (Alderson). Ulcers on the anterior wall are unusual, do not tend to form adhesions, and are apt to perforate. It is not very unusual to have ulcer of the first portion of the duodenum associated with gastric ulcer. Disorders of menstruation may develop ulcer, so may tight lacing, and habitually bending over, as in making shoes. The grinding action of the pyloric portion of the stomach may be an exciting cause (Mayo). Chlorosis is associated with ulcer in many cases. Traumatism and swallowing corrosive liquid may lead to ulceration. Alderson believes that alcoholism, syphilis, and mental anxiety may lead to the condition. Ulcers due to syphilis and tuberculosis are not, be it remembered, peptic ulcers. Gastric ulcer is at least four times as frequent in England as in the United States. In 2830 autopsies made in the Philadelphia Hospital there were 40 gastric ulcers, and in 3763 autopsies made in 4 Philadelphia institutions there were 51 gastric ulcers—a percentage of 1.35 (see A. P. Francine in "Proceedings Phil. Co. Med. Soc.," March 31, 1905).

Symptoms.—In an acute ulcer the symptoms are often typical; there is pain, usually aggravated by food, tenderness on pressure, and there are vomiting, hemorrhage, and hyperchlorhydria. In a chronic ulcer the symptoms may be clear, may be misleading, may be variable, and in some cases even absent (*latent ulcer*). In ulcer acid dyspepsia usually exists, associated with much flatulence. In most cases, though not in all, food aggravates the condition. In many of these patients vomiting occurs about two hours after eating. The vomited matter contains much hydrochloric acid. Hemorrhage from the stomach occurs in about one-half of the cases, and from 3 to 8 per cent. of cases actually die of hemorrhage. The blood may be brought up with food, and is then black and clotted, or may be vomited clear and in large amount. Blood may be present in vomited matter or stools in such small amount that its presence is obvious only by the microscope. In hemorrhage from an acute ulcer a pint or two may be ejected in a few minutes, and such a patient presents all the general symptoms of dangerous hemorrhage. In some case blood from the stomach is passed by the bowels in part or wholly. A very large hemorrhage may occur, and yet the bleeding never be repeated, or a large hemorrhage may be followed by another or be the first of three or of a series. In a great many cases after a large hemorrhage there is no further bleeding or there are subsequently a few small hemorrhages. Small hemorrhage may recur indefinitely, and may after a time eventuate in a large hemorrhage. In chronic ulcer in which small hemorrhages recur over a long period the condition is due to bleeding from congested mucosa or to the erosion of small vessels which cannot contract or retract because they are imbedded in fibrous tissue. A large hemorrhage may be due to the erosion of a large vessel, but is often produced by the existence of a great number of erosions of the mucous membrane, erosions perhaps so numerous that blood seems to pour from every portion of mucous surface. In a sudden acute, violent hemorrhage there will probably be no history of antecedent stomach trouble. In ulcer paroxysmal pain exists—in most cases pain which is usually, but not invariably, aggravated by taking food. The pain is very violent in the abdomen, and also passes to the back, being located between the eighth and ninth dorsal vertebræ.

In gastric ulcer it is usual to find tenderness developed by epigastric pressure.

If the ulcer does not cicatrize, but progresses, causing pain and hemorrhage, the patient becomes thinner, more anemic, weak, and even exhausted.

It is certain that many cases of gastric ulcer are unrecognized; in fact, as Habershon says, diagnosis is rarely made unless hemorrhage exists, and in certain latent cases both vomiting and bleeding are absent. It is believed that latent ulcers are even more common than are ulcers causing symptoms.

A gastric ulcer may cicatrize and thus be cured, but the cure of the ulcer may prove the ruin of the stomach by producing stenosis of one of the stomach orifices or hour-glass contraction of the body of the stomach. An ulcer may perforate and does so in about 15 per cent. of cases (Robson). A *perforation* may be *acute;* that is, the ulcer suddenly breaks open when the stomach contains food or liquid, and the contents of the stomach are poured into the free peritoneal cavity. A *subacute* perforation occurs when the stomach is empty or nearly empty. The opening is small in size, there is no escape of stomach-contents or the escape of only a small amount, and the opening may be quickly closed by adhesions to an adjacent surface of peritoneum or a piece of omentum. If a certain amount of stomach-contents is extravasated, it is usually surrounded by adhesions or tracks slowly toward the pelvis. In what is known as a *chronic* perforation the break takes place usually in the posterior wall into a box of preformed adhesions, the extruded gastric contents are circumscribed by these adhesions, the general peritoneal cavity is not invaded, but circumscribed suppuration is inaugurated.* This condition is known as *perigastric abscess*, and the subphrenic form is the commonest. In such a case the abscess may break into the pleural cavity or even into the lung. I recently operated on a girl of sixteen and found a perigastric abscess and a perforation of the anterior wall near the pylorus, and this condition was tuberculous. A fistula persisted for months, but finally healed.

Perforation is usually brought about by muscular effort and is most common after a full meal. In acute perforation food is the most active cause, in chronic perforation, muscular effort. "The severity of the symptoms depends upon several conditions: the previous state of health, the size and number of the perforations, the condition of the stomach, whether full or almost empty, the bacterial virulence of its contents, and the occurrence of vomiting." †The situation of the ulcer has some influence on the symptoms. "If in the fundus, at the cardiac end, or in the body of the stomach, an acute infection of the whole peritoneal cavity rapidly follows; if the ulcer be at the pylorus or in the first portion of the duodenum, the fluid is directed down the right side of the abdomen, owing to the hillock formed by the transverse mesocolon at the pyloric end of the stomach" (Moynihan in "Brit. Med. Jour.," Jan. 31, 1903). In such a case the fluid may gravitate toward the right iliac region and the condition may be mistaken for appendicitis. In a case of subacute perforation I operated, believing that appendicitis existed. Alderson calls attention to the fact that the sudden perforation of an ulcer may be mistaken for poisoning, and he cites the death of the Duchess of Orleans in 1670.

* See paper by B. G. A. Moynihan, Brit. Med. Jour., Jan. 31, 1903.
† Moynihan, in Brit. Med. Jour., Jan. 31, 1903.

Acute perforation can usually be certainly diagnosticated if the case is seen early. Such an emergency has usually, but not invariably, been preceded by positive and prolonged symptoms of gastric disorder. It causes sudden and violent epigastric pain, greatly increased by swallowing fluids, by vomiting, and by pressure. This pain may radiate throughout the abdomen, but the chief tenderness is in the region of the stomach. The seat of the pain after perforation does not of necessity correspond to the seat of perforation. The collapse is usually profound. In some cases death takes place quickly, but, as a rule, reaction occurs and peritonitis develops. Vomiting is rare after rupture. When it does occur, it does much harm by increasing shock and by ejecting gastric contents into the peritoneal cavity. Vomiting of blood is very unusual. Board-like rigidity exists, and it is most marked in the upper portion of the abdomen. The area of liver-dulness is in many cases diminished or obliterated. If a patient with acute perforation is not promptly operated upon, he will soon exhibit the symptoms of general peritonitis. Subacute perforation causes less violent symptoms and they come on more gradually. There is in the beginning severe but not agonizing pain, which gradually abates. Moynihan points out that there is gastric uneasiness for several days before the perforation. Peritonitis develops slowly and, as Gibbon says, the chief symptoms are often pelvic. *Chronic perforation* gives the signs and symptoms of perigastric abscess.

Treatment.—*Medical Treatment of Non-perforated Ulcer.*—Rest in bed. Rectal feeding for a time, followed by the use of a bland diet. Lavage twice a day. To some cases Carlsbad salts are given (Ziemssen), to others silver nitrate, bismuth subnitrate, or oxalate of cerium. If pain is severe, opium is required. Many are apparently cured by medical treatment. Russell's statistics show that 40 per cent. of cases were reported cured under medical treatment, but no one knows how many of those reported cured again gave evidence of the disease or later perished of hemorrhage or perforation. Further, 18 per cent. of the 500 London Hospital cases under medical treatment died.

Surgical.—Following the Mayos, we would not advise surgical treatment in acute ulcers unless complicated by hemorrhage, perforation, or obstruction; or in chronic ulcer, until careful medical treatment has failed. Operation is indicated for chronic ulcer when a mechanical cause is responsible for retention and stagnation of stomach contents, and in certain cases of hemorrhage. Operation is also indicated in chronic ulcer with frequent exacerbations, but the surgeon must be very chary of operating upon neurotic women with gastroptosis, unless, of course, there is a positive indication (Wm. J. Mayo, in "Jour. Am. Med. Assoc.," Oct. 21, 1905).

In a chronic ulcer if the patient grows worse in spite of careful dietetic and medical treatment, if hemorrhage has been profuse or if there have been frequent distinct hemorrhages, if the pain is violent, or if tenderness is marked, open the abdomen and inspect the stomach. An ulcer with indurated edges is easily found. The form, called by the Mayos the non-indurated ulcer, gives no evidence or little evidence of its existence when the outer coat of the stomach is felt and inspected (Wm. J. Mayo, in "Jour. Am. Med. Assoc.," Oct. 21, 1905). Even when the stomach is opened, no ulcer may be found. According to Mikulicz, in some mucous ulcers there is a very little thickening, and,

according to Moynihan, the mucous coat may be a little adherent to the muscular coat, so that it does not slide easily. An enlarged gland in a portion of the omentum may be a sign of ulcer (Lund). An indurated ulcer may be removed by an elliptical incision in the long axis of the stomach, the coats being sutured by the usual method, and gastro-enterostomy being also performed. I have extirpated one chronic ulcer with satisfactory results. Rodman is a warm advocate of excision. In some cases gastro-enterostomy alone leads to the cure of chronic ulcer. The Heineke-Mikulicz operation is not satisfactory in ulcer. Finney's gastro-duodenostomy is not advisable if there is an unhealed ulcer, because food still passes over the ulcer after its performance (Wm. J. Mayo). In an acute and violent hemorrhage threatening life the proper course to pursue is somewhat uncertain. It is not proper to operate for one hemorrhage, because the chances are it will not be repeated. Again, the chance of arresting such a hemorrhage by operation is, on the whole, poor. If the bleeding is from a distinct ulcer, we may succeed in excising the ulcer or in ligating the bleeding point. As a rule, however, the bleeding is not from a distinct point, but from a multitude of excoriations. In the light of our present knowledge we may lay down the following rule: Do not operate for one acute hemorrhage. Simply bring about reaction by gentle means, let the patient take bits of ice, and give suprarenal extract by the stomach. If the bleeding recurs once or twice in comparatively trivial amounts, do not operate; but if it recurs violently, we should advise operation. In cases in which bleeding in small amount persists, operation is indicated. In operating for a severe hemorrhage the surgeon opens the abdomen while hot salt solution is being thrown into a vein. The stomach is opened, the clots washed out, and a search made for the source of the blood. If it is found that the blood comes from an area of ulceration, this area may be extirpated or ligated. Some advise surrounding it with a purse-string suture. Others, notably Moynihan, simply perform gastro-enterostomy, which is of service by draining and giving rest to the dilated stomach, the hemorrhage being perhaps arrested by contraction of the gastric walls and the rest secured preventing the detachment of hemostatic clot. If it is found that the bleeding comes from a multitude of excoriations and that the stomach is, as Moynihan expresses it, "weeping blood," we can do nothing but gastro-enterostomy, which in such a condition is of uncertain value. In acute and subacute perforation operate at once, having all proper means taken to bring about reaction from shock, while the abdomen is being sterilized and while ether is being administered (hot saline enemata, external heat, atropin hypodermatically, etc.). I formerly advised to wait until reaction was established before operating. I now believe such advice erroneous; in acute perforation we may wait for what never comes. Open the abdomen at the point of greatest tenderness, or, if there is no such point, in the epigastric region, a little to the right of the midline. When the abdomen is opened, there may be an escape of odorless gas, and food or fluid may be discovered in the peritoneal cavity. The perforation is sought for and is usually found in the anterior wall. When found, it should be buried and overlaid by stomach wall, a portion of which must be inverted by two layers of Halsted sutures. I do not believe that excision or paring the edges is necessary or desirable in a case of perforated ulcer. If no perforation is found on the anterior wall, make an

opening into the lesser peritoneal cavity through the gastrocolic omentum, explore the posterior wall, and close and cover any perforation found. In addition to closing the perforation gastro-enterostomy is theoretically indicated, in order to drain the viscus, give it rest and lessen the tendency to recurrence of ulceration. But, as a matter of fact, such ulcers seldom return. The patient is usually too severely shocked to render such an additional operation justifiable, and I agree with Gibbon that such an operation should be performed only when there are multiple ulcers or when there is pyloric constriction (John H. Gibbon, in paper before the Tri-State Med. Assoc. of Virginia and the Carolinas, Feb. 23–24, 1904). After closing the perforation the abdominal cavity is irrigated with hot salt solution and the space between the liver and diaphragm is sponged out with a gauze pad wet with hot salt solution. If the case is operated many hours after the perforation, or if the peritoneum was badly soiled, drainage *must* be used, but even in other cases it is safest to use it. Drainage is obtained by means of a strand of iodoform gauze passed to the suture line in the stomach. In cases with much extravasation, especially if the extravasation has reached the pelvis, a suprapubic opening is made and a tube inserted. After the patient has reacted from the shock of the operation he should be placed in a semi-erect position to direct the flow of infective material to the pelvis, and continuous proctolysis should be employed as in peritonitis (page 869). The treatment of chronic perforation is the treatment of perigastric abscess, and consists of incision and drainage. Of late, a number of cases of acute and subacute perforation have been successfully operated upon. Moynihan estimates that 35–40 per cent. of acute perforations recover after operation. T. Crisp English ("Lancet," Nov. 28, 1903) reported 42 consecutive gastric perforations operated on in St. George's Hospital. Twenty-two recovered.

Cicatricial stenosis of the orifices of the stomach results from the healing of an ulcer, the swallowing of a corrosive substance, or traumatism from a foreign body. Constriction of the *cardiac orifice* is indicated by gradually increasing difficulty in swallowing. After a time the esophagus above the stricture dilates or pouches; the fluid food passes into the stomach, but the solid food lodges in the esophageal pouch and is soon regurgitated. The site of the stricture is located by a bougie, and by having the patient swallow while auscultating over the esophagus and cardiac end of the stomach. If the constriction be malignant, the patient will be found to be beyond middle life, the vomit is occasionally bloody, emaciation is rapid and decided, and occasionally the supraclavicular glands are enlarged. A tumor of the cardiac end of the stomach can seldom be palpated. If the constriction be cicatricial, the history will indicate the cause. Constriction of the *pyloric orifice* causes retention of food and dilatation of the stomach. Dyspeptic symptoms will be found to have been long present. A tube passed into the stomach permits of the injection of fluid so as to fill the stomach. When the fluid runs out, it contains portions of undigested food, which was perhaps eaten days before, and measurement of the liquid shows that the capacity of the stomach is enormously increased. If hydrogen be forced through the tube, the outline of the distended stomach is at once made clear. The usual method of distending the stomach is by a Seidlitz powder: two solutions are made; the bicarbonate solution is swal-

lowed at once, and the tartaric solution is taken afterward in small amounts at a time. Percussion over the distended stomach indicates the size of the viscus.

In malignant disease of the pylorus a tumor may often be made out; there are tenderness and considerable persistent pain, great cachexia and emaciation, absence of free hydrochloric acid from the gastric juice, diminution of red corpuscles and hemoglobin, and no increase of white corpuscles after a full meal. There is sometimes enlargement of the supraclavicular glands. Vomiting of bloody fluid occurs in 40 per cent. of the malignant cases. Illumination of the stomach by the gastrodiaphanoscope may aid the diagnosis, the area of malignant growth interfering with the transmission of light. In cicatricial stenosis of the pylorus there may be paroxysms of pain, there is no tenderness, emaciation is not so rapid in onset, and the supraclavicular glands are never enlarged. Vomiting occurs, but the ejected matter is not bloody.

Treatment.—Cicatricial cardiac stenosis requires dilatation with bougies and the maintenance of the restored caliber. If dilatation from above is unsatisfactory, perform a gastrotomy, push a small bougie from the mouth into the stomach, tie a string to the bougie, draw the string through the stricture, use the string as a saw to cut the fibrous bands, pass a full-sized bougie, close the wound in the stomach, and maintain the caliber of the cardiac orifice by the repeated passage of dilating instruments. If no instrument can be passed through the stricture from above, perform a gastrotomy, introduce an instrument from below and pass it into the mouth, tie a string to it, draw the string into the stomach, and use Abbe's string-saw (page 805). If no instrument can be passed from below, convert the gastrotomy into a gastrostomy. In malignant stenosis of the cardia gastrostomy, if performed at all, should be performed early. Cicatricial pyloric stenosis was once treated by a gastrotomy and digital divulsion of the stricture (*Loreta's operation*); but this operation is obsolete, experience having shown that recontraction is inevitable. Pyloroplasty was until recently advocated by many surgeons. This is known as the Heineke-Mikulicz operation. In 30 per cent. of the cases the symptoms are not relieved by pyloroplasty, a condition which renders gastro-enterostomy necessary. Mayo points out that in such cases pyloroplasty fails because the pylorus is on a higher level than the gastric pouch, the degenerated muscle of the stomach is unable to lift the food from the pouch to the pylorus, and the symptoms of gastric dilatation and retardation of the passage of food into the duodenum are not relieved. The operation has been generally abandoned. Finney's method of gastro-duodenostomy (Figs. 477, 478, 479, and 480) is a great improvement on pyloroplasty. The opening is large and in a proper position to afford satisfactory drainage. Gastro-enterostomy is the most satisfactory operation in most cases and usually effects a cure. Malignant stenosis is treated by pylorectomy or gastro-enterostomy. (See under these heads respectively.)

Congenital Stenosis of the Pylorus.—Stenosis of the pylorus in adults is almost invariably due to cancer or to ulcer, but in very young children one occasionally meets with a form that is congenital. The history of such a case is that during the first two or three days after birth the child seems in every way normal; but that after several or a number of days, or a number of weeks, vomiting suddenly begins—vomiting for which no dietary

cause seems responsible, and which persists irrespective of medication. After the stomach has been emptied by vomiting, the child seems much relieved; but when, after a time, food is administered, vomiting will begin again, either in a very short time, or after an hour or so. It has been noted that the vomited matter in congenital stenosis of the pylorus never contains any bile whatever, for obvious reasons—the pylorus is shut, and the bile cannot enter the stomach. A child in this condition receives little or no nourishment, becomes quickly emaciated, and soon dies. Some of these children die in a month; others, in several months; and a few may live for five or six months. It may be possible, in these cases, to palpate a thickened pylorus; and the outlines of the dilated stomach can probably be made out. The intestines are very much collapsed; and the child is, of course, very much constipated. The treatment for this condition is gastro-enterostomy. The mortality after the operation is apparently in the neighborhood of 40 per cent.

Perigastric Adhesions.—That perigastric adhesions are frequently responsible for stomach pain and digestive difficulty is undoubted. Such adhesions often arise in cases of protracted ulceration of the stomach or duodenum. A common cause of perigastric adhesions is gall-stone disease. Tuberculous peritonitis causes dense adhesions. In some cases the adhesions are traumatic, in some they are due to syphilis, in many the cause is uncertain (Fred. D. Bird, "Intercolonial Med. Jour. of Australasia," Dec. 20, 1900). Adhesions may cause blocking or kinking of the pylorus, or may glue the stomach to the parietal peritoneum or to some adjacent viscus. In Fenwick's table of 123 cases he finds that the adhesions usually cause the stomach to adhere to the pancreas or to the liver. The formation of adhesions in cases of gastric ulcer is, in many instances, conservative, serving to prevent perforation or to limit extravasation if perforation of the stomach-wall occurs.

Symptoms.—The symptoms are variable. In some cases the adhesions produce little or no trouble; but in the majority of cases they cause definite symptoms, and sometimes the condition becomes one of absolute disablement. The symptoms may be due to blocking of the pylorus, a condition that is followed by gastric dilatation. They may be due to dragging upon the adhesions, when the stomach contracts during digestion, or when peristalsis occurs in an adherent piece of intestine.

The usual symptom is pain, frequently of a violent character. The pain comes on in paroxysms, and recurs over and over again, it may be for years. H. Hale White* points out that in these cases there is usually some pain persisting, which is now and then increased into violent paroxysms; and that the only other condition that produces persistent pain with violent exacerbations is cancer. In *adhesion-dyspepsia*, however, there is no distinct loss of weight; the condition may exist in youth, as well as in middle age or old age; it is not increased by taking food; and it very rarely causes death. If there is a history of antecedent gall-stone disease or of ulcer of the stomach, it is possible to make the diagnosis without exploratory operation. Even in other cases the condition may sometimes be diagnosticated, because, although there are these attacks of violent pain, there is no tenderness. In rare cases the adhering and matting together with inflammatory exudate produces a palpable mass. In doubtful cases of chronic and disabling stomach-disease

* Lancet, Nov. 30, 1901.

an exploratory operation should be performed; if adhesions exist, they will then become manifest.

Treatment.—In some cases simply dividing an adhesion effects a cure; in other cases it is necessary to make extensive separation of adherent structures, covering the raw surface with omental grafts. In serious adhesions about the pylorus gastro-enterostomy is usually the proper operation.

Bilocular Stomach (Hour-glass Stomach).—Some few cases are congenital, but the majority are acquired and result from adhesions produced by the healing of an ulcer. In hour-glass stomach with a large opening between the two sacs there may be no symptoms. When the opening is small, the symptoms resemble those of pyloric stenosis. The sac toward the cardia is frequently much dilated. C. G. Cumston* points out that in a congenital bilocular stomach an ulcer is apt to form at the seat of constriction.

Symptoms.—The diagnosis of cancer is often made. The protracted gastritis may have caused free hydrochloric acid to disappear and acids of fermentation are usually found. The patient vomits from time to time, bringing up food which was eaten a day or two before, proof that food is retained in the stomach and not digested. Occasionally perhaps blood is vomited. There is pain and the patient is harassed with foul-smelling eructations. Emaciation is pronounced. Cumston points out that in a thin belly distention of the stomach may make the condition evident; further, that if water is thrown into the stomach, only a part returns, and when the stomach is emptied as much as possible by a tube, a splashing sound can still be elicited in the stomach because the pyloric pouch is not empty. One cause of death is torsion on the axis.†

Treatment.—The diagnosis becomes certain only after exploratory operation, and exploration also enables the surgeon to decide with certainty as to what operation should be performed. Cumston gives us the following suggestions:

1. In rare cases resect the stricture and suture the pouches.
2. If there is trivial ulceration or a slight scar, do an operation upon the constriction exactly similar to pyloroplasty.
3. The best operation in most cases is gastro-gastrostomy—that is, anastomosis of the cardiac pouch to the pyloric pouch; but this cannot be done if the pyloric pouch is small. Then do gastro-enterostomy.

Other operations are:

4. Gastro-duodenostomy.
5. Gastro-jejunostomy.
6. Gastrolysis.‡

Chronic Dilatation of the Stomach.—A dilated stomach, roughly speaking, is one which can contain more than 1.5 quarts (Ewald). Some few cases of dilatation result directly from atrophy of the muscular coat, brought about by drinking quantities of liquid, especially beer; chronic catarrh of the stomach; and conditions such as cancer, tuberculosis, diabetes, etc. The common cause of dilatation is constriction of the pylorus. In order to force food by the pyloric narrowing more force is necessary than

* Med. News, Dec. 7, 1901. † Cumston, in Med. News, Dec. 7, 1901.
‡ Med. News, Dec. 7, 1901.

is required in a normal state of affairs and the stomach muscle hypertrophies. This muscular hypertrophy is compensatory, and dilatation does not occur so long as the muscle is efficient. But finally the pyloric opening becomes so narrow that compensation fails, the stomach-contents accumulate, and the stomach dilates.

Symptoms of Dilated Stomach.—There is annoying hunger unless cancer exists. Thirst is complained of. At intervals of a day or two the patient vomits enormous quantities, and portions of food may be identified which were eaten several days before. The vomited matter is sour and foul-smelling, contains numbers of yeasts and much fermentative acid. Free hydrochloric acid is often absent. In some cases vomiting occurs two or three hours after each meal. The patient suffers from foul gaseous eructations. There are progressive emaciation, constipation, scantiness of urine; sometimes cramp in the legs, belly, and arms; tetany may occur; insomnia is the rule; cardiac palpitation occurs, and there is dyspnea, particularly at night.

Physical Signs of Dilated Stomach.—The epigastric region is hollow and the left side of the abdomen is more prominent than the right. The outline of the greater curvature of the stomach can be distinguished. If the stomach contains air, percussion gives a tympanitic note; if it contains fluid, a dull note. When it is partly full of fluid, by altering the position of the patient we can show by percussion that the fluid changes its position. In a doubtful case give a light meal in the evening, and in the morning, before the patient has eaten, introduce a tube and remove any material contained in the stomach. The presence of undigested food points to dilatation.

To Test the Motor Power of the Stomach.—*Klemperer's Test.*—Wash out the stomach. Introduce 100 c.c. of olive oil by means of the tube. After two hours withdraw the oil. The stomach cannot absorb oil, and if the amount withdrawn is subtracted from the amount introduced, the difference is the amount which passed the pylorus. If the condition is normal, not more than from 20 to 40 c.c. should be found in the stomach after two hours.

The Salol Test of Ewald.—Salol is not decomposed in the stomach, but in the intestine is broken up into phenol and salicylic acid. Salicylic acid is absorbed and salicyluric acid soon appears in the urine. If salol cannot reach the intestine, salicyluric acid will not appear in the urine. If salol reaches the intestine more slowly than normal, salicyluric acid will appear after a longer interval than when there is no pyloric block to retard the emptying of the stomach. In a normal person salicyluric acid is found in the urine in from three-fourths of an hour to an hour after swallowing a dose of salol. In stenosis of the pylorus it appears much later. The test is made as follows : The bladder is emptied and the patient is given three capsules, each containing 5 gr. of salol. The patient is directed to pass water every half-hour until he has done so four times. Each sample voided is examined for salicyluric acid by adding neutral chlorid of iron. If salicyluric acid is present, a violet color is noted.

To Test the Absorptive Power of the Stomach.—The absorptive power of the stomach can be tested by giving the patient a capsule containing $1\frac{1}{2}$ gr. of iodid of potassium. Normally the drug should be found in the saliva in from ten to fifteen minutes. When absorption is deficient, it may

not appear for an hour or longer. In order to test for it, moisten starch paper with the saliva and touch the moist paper with a drop of fuming nitric acid. If iodin is present, a blue color develops.

While the diagnosis of dilatation of the stomach can be certainly made, the determination of the cause may require an exploratory operation.

Treatment.—Cases not due to pyloric obstruction are much improved by lavage, regulated diet, use of an abdominal belt, electricity, aperients, and other agents called for by symptoms.

In all cases where there is pyloric obstruction, in many doubtful cases, and in cases in which medical treatment fails, exploratory operation is indicated. In dilatation without pyloric obstruction some surgeons advocate gastroplication. If pyloric obstruction exists, the surgeon may elect to do pylorectomy, pyloroplasty, or gastro-enterostomy, the method selected depending on the condition discovered. If gastroptosis exists, gastropexy or Beyea's operation may be performed.

Acute Dilatation of the Stomach.—This condition may arise in the course of chronic dilatation or when no previous dilatation existed. The cause is uncertain. It is said to be due to degeneration of the gastric muscle in the course of specific fevers, to paresis arising in the course of chronic gastritis, and to the drinking of a quantity of effervescing liquid. The surgeon sees it from kinking or sudden blocking of the pylorus or duodenum, in the course of sepsis and during shock. It is occasionally a fatal sequence of abdominal operations, particularly operations upon the gall-bladder and bile-ducts.

Symptoms.—These are violent vomiting, sudden in onset, pain, frequently cyanosis, the same physical signs met with in chronic dilatation and collapse. Death occurs in most cases.

Treatment.—Wash out the stomach at frequent intervals, give no food by the mouth, and combat shock and sepsis by proper methods.

Gastroptosis.—In this condition the stomach has undergone displacement downward, the greater curvature in many cases being but little above the pubic symphysis and the lesser curvature being between the ensiform cartilage and the umbilicus. This condition is far more common in women than in men, and is especially common in women who have had many children. It may be produced by tight lacing and may follow movability of the right kidney, of the liver, or of the spleen. It is often associated with enteroptosis and is particularly prone to arise in the anemic and tuberculous.

Symptoms.—There may be no symptoms for a long time, but sooner or later dyspepsia arises because the stomach cannot empty itself. The stomach becomes atonic, its secretions are scanty and altered, and while the viscus may be normal in size or even shrunken, it is usually dilated. The malposition can be made out by percussion when the stomach is distended with air or with fluid.

Treatment.—Lavage, regulation of diet, improvement of the general health, and the wearing of an abdominal binder. If medical treatment fails and the condition is producing grave impairment of the general health, perform gastropexy or Beyea's operation.

Intestinal Obstruction (Ileus or Enterostenosis).—Intestinal obstruction is a condition in which fecal movement is mechanically impeded

or prevented. It may be either *partial* or *complete*. *Acute obstruction* is due to a sudden narrowing or occlusion of the lumen of a portion of the intestine. *Chronic obstruction* is due to a gradual narrowing of the lumen of a portion of the intestine, and it may at any time become acute. If obstruction to circulation in the wall of the bowel occurs, the condition becomes one of strangulation. Intestinal obstructions are classified * as follows:

1. *Strangulation by bands or in apertures*, the commonest form, is due to peritoneal adhesions, but the band may come from the omentum. Strangulation by bands or in apertures usually involves the ileum, and sometimes the colon. This form of obstruction is identical with hernia, except in the absence of an external protrusion. Obstruction may take place by *Meckel's diverticulum* (page 840), a structure due to persistence of the vitelline or omphalomesenteric duct, and coming off from the ileum from twelve to thirty-six inches above the ileocecal valve. The vitelline duct should be obliterated in the eighth week of fetal life. A Meckel's diverticulum usually has no mesentery, is from 3 to 10 inches long, and arises from the convex side of the gut. It may hang free or may be attached to the umbilicus by its tip or by a fibrous cord formed by the obliterated tip. In some cases it remains open at the umbilicus (page 342). In other cases a cord runs from the umbilicus to the gut or the tip of the diverticulum or is adherent to another portion of the intestine. The diverticulum may become strangulated, may enter a hernial sac, may ulcerate or perforate like an appendix (W. Sheen, in "Bristol Medico-Chir. Jour.," Dec., 1901, gives an admirable account of "Some Surgical Aspects of Meckel's Diverticulum"; see also article on "Obstruction of the Bowels by Meckel's Diverticulum," by James E. Moore, in "Journal of Am. Med. Assoc.," Oct. 4, 1902, and on "Abdominal Crises Caused by Meckel's Diverticulum," by Miles F. Porter, in "Jour. of Am. Med. Assoc.," Sept. 23, 1905). Strangulation of the diverticulum may take place beneath an adherent appendix, a Fallopian tube, a portion of mesentery, or the pedicle of an ovarian tumor, or it may take place in an omental or a mesenteric aperture.

2. *Volvulus*, or twisting of the bowel. The twist may be about the mesenteric axis or on the axis of the bowel itself, or two intestinal coils may be twisted together. Volvulus is commonest in the sigmoid flexure. It may occur in a hernial sac.

3. *Intussusception* is the invagination of a portion of bowel-wall into the lumen of an adjacent part of the gut. One-third of all cases of obstruction are due to this cause (Treves). Most cases of obstruction in children are due to intussusception. Pitt reports that in St. Thomas's Hospital, from 1875 to 1900 inclusive, there were 115 cases of intussusception, and every patient was under fifty years of age. Gibbon's patient was fifty-eight. Rutherford Morrison had a case due to polypus, and the patient was sixty-two years of age. There are four varieties: the *ileocecal*, in which the ileum and the ileocecal valve pass into the cecum and colon; the *colic*, in which the large intestine is prolapsed into itself; the *ileal*, in which the small intestine alone is involved; and the *ileocolic*, in which the ileum prolapses through the ileocecal valve. The first variety is the commonest. Intussusception is due to active peristalsis.

* After Treves, in "Heath's Dictionary."

4. *Stricture of the intestine*, which may be either cicatricial or cancerous.

5. *Obstruction by Tumors of the Bowel and by Foreign Bodies.*—Tumors may be innocent or malignant. Foreign bodies include, besides certain substances that have been swallowed, gall-stones and enteroliths or intestinal calculi. Foreign bodies are apt to lodge in the lower portion of the ileum or in the cecum, and they may cause ulceration at the seat of lodgment. If a gall-stone is sufficiently large to cause obstruction, it cannot have passed the duct, but must have ulcerated into the bowel from the gall-bladder. About three-fourths of the cases of gall-stone intestinal obstruction occur in women. The stone is arrested at some point, because a local paralysis of the bowel has developed.

6. *Obstruction by tumors, etc., outside the bowel*, among the causes of which are retroflexion or retroversion of the womb, especially in pregnancy, cysts or tumors of the kidneys, ovaries, uterus, etc., movable kidney, and enlarged spleen. Obstruction from any of the above causes takes place in the rectum or the sigmoid flexure.

7. *Obstruction from fecal accumulation* is due to paresis or paralysis of the bowel and the diminution or abolition of peristalsis. Obstruction may follow an abdominal operation. Paresis or paralysis arises in the colon. Treves mentions among the rare forms of obstruction kinking of the bowel, adhesions matting the bowels together or compressing the gut, and shrinking of the mesentery.

In addition to the seven groups previously mentioned, we should consider *postoperative intestinal obstruction* and *obstruction from embolism or thrombosis of the mesenteric vessels.* Obstruction of the mesenteric vessels is liable to occur when the aorta is atheromatous, and usually causes gangrene of the intestine.

Symptoms of Acute Obstruction.—Severe colic comes on suddenly, the pain varying in intensity, but at no time entirely ceasing. In a suddenly arising intraperitoneal accident, whether it be perforation, acute obstruction, or acute strangulation, there is at first shock, from which the patient usually reacts for a time. In obstruction there is constipation, which soon becomes absolute, not even gas being passed; vomiting is early—first of the contents of the stomach, next of bilious matter, and finally of feces (*stercoraceous vomiting*); the abdomen becomes distended and tender. After reaction from shock some fever may be noted, but in any unrelieved case collapse soon arises; the temperature becomes subnormal; the face, Hippocratic; the pulse, rapid and feeble. The amount of urine passed is very small. In obstruction of the upper third of the ileum true fecal vomiting cannot occur. If obstruction is high up in the small intestine, tympanites does not occur. The tongue is dry, the mind is clear, and muscular cramp may occur. Intestinal peristalsis above the obstruction may be detected through the abdominal wall. Tapping is more apt to cause pain than is pressure; in peritonitis pressure is more apt to cause pain than tapping (Battle). In intestinal obstruction (postoperative and primary) there is a leukocytosis of from 15,000 to 30,000 (Bloodgood, in "Johns Hopkins Hospital Reports," vol. vii).

Symptoms of Chronic Obstruction.—At intervals there arise attacks of pain which become gradually more frequent and severe, and are linked with vomiting and constipation, the vomiting not being stercoraceous and the constipation not being absolute. Between the painful seizures the patient

complains of constipation alternating with fluid diarrhea, distention of the belly, some abdominal uneasiness, anorexia, and dyspepsia. The attacks recur with increasing frequency and severity, and acute obstruction may arise or the patient may be worn out by pain, vomiting, and want of food.

Diagnosis.—*The determination of the seat of lesion* requires abdominal and rectal examination. An intussusception may sometimes be felt by a finger in the rectum. Vaginal examination may be demanded. Pain is apt to arise at the seat of obstruction or to radiate from there. Abdominal palpation may detect a tumor. Rectal insufflation of hydrogen may locate the obstruction by causing great distention below it. Entire suppression of urine, early vomiting, which is not truly stercoraceous, absence of abdominal distention, and rapid collapse mean obstruction in the duodenum or in the jejunum. Early vomiting, which is often stercoraceous in a rapidly progressive case, with great distention of the umbilical region, means obstruction of the ileum or the cecum. Distention of the entire abdomen and of the flanks, linked with tenesmus, with less violent symptoms, less rapidity of progress, and less diminution of urine than in the above-cited forms, means obstruction low down in the colon or in the rectum. A test for obstruction in the adult large intestine is an injection by a fountain-syringe: if six quarts can be introduced, there is no obstruction in the large intestine; if less than four quarts can be introduced, there is probably obstruction in the large intestine. The passage of a sound in the rectum is generally useless and is often unsafe. In many cases the seat of the lesion and the cause of the obstruction can be determined only by exploratory laparotomy.

The determination of the causative condition is always difficult and is often impossible. *Intussusception* is the common cause in children. A sausage-shaped tumor can usually be felt in the right iliac fossa, tenesmus exists, and bloody mucus is passed. The abdomen is rarely distended or tender. Vomiting occurs, but it is seldom stercoraceous. The prolapse may sometimes be detected by digital exploration of the rectum. In *obstruction from bands, internal hernia*, etc., there is a record of antecedent peritonitis, of a traumatism, of a violent effort, or of pelvic pain. The attack is sudden in onset, is fierce in character, and is usually excited by violent exercise or the taking of food. Vomiting is early and intractable, and it soon becomes stercoraceous; pain is violent; peristalsis above the obstruction is forcible; tympanites and abdominal tenderness appear after the attack has lasted for some little time; obstruction is complete, no gas even being passed; collapse soon arises; no tumor can be detected, and rectal examination is negative. *Volvulus*, which is usually located in the sigmoid flexure, is preceded by constipation. The symptoms come on with explosive suddenness, and rapidly attain great severity. Constipation is absolute; vomiting is late and is rarely stercoraceous; no tumor can be detected; rectal examination is negative; abdominal distention and tenderness are early and pronounced; peristalsis above the volvulus is vigorous; collapse is not so rapid nor so grave as in obstruction from bands and internal hernia. *Obstruction by a foreign body* may sometimes be inferred from the history of some such body having been swallowed. The obstructing body may occasionally be felt during palpation, or may be discovered with the x-rays. Abdominal distress may exist for days or weeks before obstruction occurs. Vomiting is late and is rarely severe,

but pain, tenderness, and distention are marked. In *obstruction from gall-stones* there will be a record of one or more attacks of hepatic colic. Pain is early and acute, and vomiting is invariable and usually becomes stercoraceous. In *obstruction from fecal accumulation* chronic obstruction evolves into acute obstruction, pain and vomiting are late or even absent, and the doughlike mass of feces may be felt by rectal examination or by abdominal palpation. In some cases the fluid elements of the feces pass, but the solid elements agglutinate to the walls of the bowel (the *diarrhea of constipation*). *Obstruction from stricture or from pressure* comes on acutely after a prolonged period of disturbance, during which period attack after attack of temporary obstruction, complete or partial, takes place. A history of blood or pus in the stools would indicate *tumor of the bowel;* a history of *blood* or pus having been absent would indicate pressure from without. In *functional obstruction* there is no local pain, no tenderness, no tumor, no tendency to collapse, but simply distention and absolute constipation, and possibly non-fecal vomiting occurring in a neurotic or hysterical subject. A *phantom tumor* due to a local distention of the intestine from limited muscular spasm disappears under ether. *Obstruction of the mesenteric vessels* causes abdominal pain, but early in the case there is no tenderness, rigidity, or distention. Moderate vomiting may occur, there is great restlessness, and sometimes bloody diarrhea. Obstruction may follow an abdominal operation (*post-operative obstruction*); it may arise a day or so after operation; it may arise in ten or twelve days after operation; it may not arise for weeks or months (Legeve). It may be due to some cause at the seat of operation (adhesion of the bowel to a raw surface, volvulus, catching of the intestine under adhesions, etc.). It may be due to some cause distant from the seat of operation (displacement of intestine, bands, etc.). It may arise from paralysis of a portion of the bowel, which may or may not be due to sepsis.* It may be due to thrombosis of a mesenteric vessel. The symptoms of *postoperative thrombosis of the mesenteric vessels*, according to A. E. Maylard,† are as follows: Abdominal pain, perhaps colicky in character, gradual or acute in onset, and, as a rule, constant. Early in the case there is no abdominal tenderness, no distention, and no rigidity. The pulse is rapid, the patient is extremely restless, there may be vomiting, but it is never violent, as in acute obstruction; often there is diarrhea, and sometimes bloody diarrhea. These symptoms become particularly significant if there is cardiac or vascular disease. *Obstruction from Meckel's diverticulum* is usually acute, but is sometimes chronic, and occurs particularly in young adults and children. It has been stated that other and visible deformities are usually present, but in a study of 69 cases by A. E. Halstead ‡ this was true of but one case, in which harelip existed. In obstruction from Meckel's diverticulum there is often a history of former mild attacks (Halstead). Halstead sums up the symptoms as follows: As the obstruction is high up, the abdomen is the shape of an inverted cone; early in the attack there is often local meteorism, especially under the costal arch of the right side, but there is no distention in the flanks. Early, active peristalsis may be visible. The tenderness is just to the right of the umbilicus, on a level with it or below it. In most cases there is early fecal vomiting.§

* Legeve, Gaz. des Hôp., Nov. 23, 1895.
† Brit. Med. Jour., Nov. 16, 1901.
‡ Annals of Surgery, April, 1902.
§ Annals of Surgery, April, 1902.

Differentiation of Intestinal Obstruction from Other Diseases.—Always examine for a strangulated hernia at every hernial outlet. If obstruction is complicated with an irreducible hernia above the seat of lesion, the hernia will always enlarge and become tender because of accumulation of feces. Functional obstruction may attend peritonitis or may follow the reduction of a hernia. Appendicitis with peritonitis may cause symptoms similar to those of obstruction; but there are fever, a history of pain in the right iliac fossa, and the vomiting is not stercoraceous. Acute pancreatitis produces symptoms so similar to those of intestinal obstruction that a diagnosis cannot always be made. Poisoning by arsenic or by corrosive sublimate should not be confounded with intestinal obstruction.

Prognosis.—Without surgical interference most cases of acute intestinal obstruction die within ten days—usually within seven days. Death may be due to shock, to exhaustion, to perforation, to peritonitis, or to obstruction of respiration and circulation by tympanites. Recovery occasionally happens by the formation of a fistula externally or into another portion of the bowel. In acute obstruction from foreign bodies the obstructing body occasionally passes. Volvulus and strangulation by bands are almost invariably fatal unless an operation is performed. In intussusception recovery occasionally follows the sloughing away of the prolapsed gut, but stricture almost inevitably results from this rare event. Functional obstruction gives a good prognosis. The prognosis of chronic obstruction depends upon the causative lesion. It does not threaten life immediately to anything like the degree that acute obstruction does.

Treatment.—In any abdominal case in which the diagnosis is uncertain and the patient is shocked give an enema of brandy and hot water, wrap the patient in blankets, surround him with hot-water bottles, and study the development of symptoms and signs. In half an hour, as a rule, reaction will be brought about, and a probable diagnosis may be made (Greig Smith). In acute obstruction it is usually customary to empty the stomach by lavage and to evacuate the rectum by means of copious injections given while the patient is in the knee-chest position. The emptying of the stomach is imperative if stercoraceous vomiting has been going on, for vomiting of a quantity of such material while a patient is under ether may cause death by drowning, the fluid flowing in enormous quantity into the bronchi. In very severe cases a general anesthetic cannot be given and the belly must be opened under cocain. Hutchinson's method of taxis and massage is uncertain, and is as liable to inflict harm as to confer benefit. Some surgeons apply constant compression to the abdomen by means of straps of adhesive plaster. Puncture of the intestine with an aseptic hypodermatic needle introduced obliquely to relieve gaseous distention is a decidedly dangerous proceeding. The passage of a small tube from the anus to the sigmoid flexure will empty the colon of gas if no obstruction intervenes. In intussusception give no food by the stomach; administer opium and belladonna to arrest peristalsis, wash out the rectum with copious injections, give an anesthetic, and insufflate hydrogen gas or carbonic-acid gas in order to distend the bowel. Some surgeons treat intussusception by forcing air into the rectum by means of an ordinary bellows, and others inject water by a fountain-syringe, the reservoir at a height of three feet. D'Arcy Power believes in the value of hydrostatic pressure in intussus-

ception in children. He states that the child should be anesthetized and the large intestine filled *gradually* with hot saline fluid, the reservoir not being raised more than three feet above the patient. The fluid should be retained for ten minutes. The author is of the opinion that whereas it is justifiable to try to reduce by gaseous or hydrostatic pressure during the first twenty-four hours of the attack, early operation gives a better prognosis and is safer and more certain. After the first twenty-four hours it is not justifiable to use gaseous or hydrostatic pressure because ulcer or gangrene may exist. Pressure cannot be accurately regulated, and if the bowel is much damaged, may lead to rupture. If the case is not seen until after the first day, or if injections have been used and have failed, laparotomy should certainly be performed.

Frederick Holme Wiggin has made a study of the reported cases of laparotomy for infantile intussusception, and considers that operation done within the first forty-eight hours will give a mortality of 22.2 per cent.* (see Operation for Intussusception).

In obstruction of the main mesenteric vessels operation is of no avail. In obstruction of branches it may be possible to resect the involved region of bowel, a region which is found to be gangrenous or at least is becoming so.

In obstruction from fecal impaction use large rectal injections and give small repeated doses of salines or of castor oil. If there are signs of inflammation, do not give cathartics, even in small doses, but give opium and belladonna to arrest vomiting and to relax spasm. Impactions in the rectum can be removed by the use of a spoon. In acute intestinal obstruction, if the symptoms grow worse, do not wait, but open the abdomen before collapse comes on and find the cause of the obstruction. If it is a gall-stone or enterolith, try to crush it without opening the intestine; if this fails, push it up a little distance, incise the bowel, remove the stone, and close the incision with Halsted sutures. Pilcher † reports 40 cases operated upon for gall-stone obstruction with 21 deaths. If there is fecal obstruction, break up the masses by pressure and push the fecal plug down without opening the bowel. If there is intussusception, reduce the prolapse and shorten the mesentery; but if reduction is impossible, perform an anastomosis or a resection and enterorrhaphy, or make an artificial anus. In volvulus untwist and shorten the mesentery; but if this is impossible, treat as an irreducible invagination. In obstruction from adhesions try to separate them and straighten out the bowel, stitching healthy peritoneum over each raw spot to prevent recurrence. Anastomosis may be necessary. In flexion separate the intestines, remove the flexion by a V-shaped incision, and suture the wound in the bowel (Senn). In chronic obstruction it is often advisable to perform an exploratory laparotomy, discover the condition, and determine what is to be done to correct it. Some tumors external to the bowel may be removed. Growths in the bowel-wall may be removed by resection of the involved portion of intestine, or an anastomosis may be performed, or it may be necessary to make an artificial anus. In obstruction from Meckel's diverticulum that structure may be found twisted, the gut near it may be kinked or twisted, or the diverticulum may act as a band, the bowel being caught under it or kinked over it. Intussusception of the gut below it sometimes occurs; so does invagination of the mucous mem-

* Med. Record, Jan. 18, 1896.
† Med. News, Feb. 8, 1902.

brane of the diverticulum; so does chronic inflammation and cicatricial narrowing of the diverticulum or gut (Halstead). The diverticulum may be gangrenous, perforated, or cystic.

After opening the abdomen the surgeon must be guided by conditions. The diverticulum should be removed, just as the appendix is removed in appendicitis, and complications relating to the gut must be dealt with. If a patient with obstruction is very gravely shocked, I usually follow Moynihan's plan. The abdomen is opened under cocain, the incision being small. A distended coil of intestine is sutured to the peritoneum about the abdominal incision, every care being taken that the stitches do not penetrate the mucous membrane of the gut (Moynihan). A purse-string suture in now inserted so as to enclose an area of the exposed gut; an incision is made into the gut in this enclosed area, and gas and feces flow out. Paul's glass tube is passed into the gut and the purse-string suture is tied. The obstruction is thus temporarily relieved, and if the patient recovers, the causative lesion may be subsequently attacked. Francis T. Stewart has devised a method by which the bowel can be drained without any risk of infection of the peritoneal cavity, a risk which always exists in using Paul's tube. Stewart places a clamp at either extremity of the loop of bowel and surrounds it with gauze. One

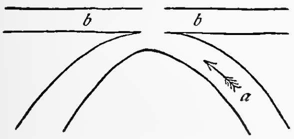


Fig. 450.—Fecal fistula: *a*, Direction of fecal flow; *b*, *b*, belly-wall.

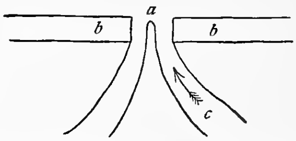


Fig. 451.—Artificial anus, showing spur: *a*, Spur; *b*, *b*, belly-wall; *c*, direction of fecal flow.

half of a Murphy button is inserted into the empty loop through a small incision. The other half of the button is squeezed into a rubber tube the diameter of which is somewhat smaller than the flange of the button. The two parts of the button are then clamped, and the clamps are removed from the loop of bowel. The intestine is sutured to the wound margins and the feces drain into a receptacle on the floor. Fig. 452 shows Stewart's operation. Postoperative obstruction coming on soon after a surgical operation is often not recognized for a time, and the surgeon will be in doubt as to whether he is dealing with peritonitis or intestinal paresis. When in doubt, wash out the stomach with warm salt solution, administer salines in small doses frequently repeated, employ enemata, and give two or three doses of atropin at intervals of two hours. Each dose should be gr. $\frac{1}{200}$. Atropin is given with the idea that it increases peristalsis and contracts blood-vessels. It is probably merely sedative, relaxes spasm, and is useless if strangulation exists. If these measures are not quickly followed by the passage of flatus or feces, open the abdomen; never wait for the advent of stercoraceous vomiting (see Legeve).

Fecal Fistula and Artificial Anus.—A fistula is an abnormal opening in the intestine through which gas or a portion of the feces escape (Fig. 450). If all the intestinal contents escape through the opening, it is called

an *artificial anus* (Fig. 451, Senn). A surgeon may make a fistula deliberately (*intentional fistula*). A fistula may be the product of disease or injury (*accidental fistula*). Senn enumerates the following causes of accidental fistula: wounds, injury of the intestine, intestinal ulceration, intestinal strangulation, foreign bodies in the intestinal canal, malignant tumors, actinomycosis, pelvic and abdominal abscess, appendicitis, injury of the bowel during an abdominal operation, the application of ligatures, catching by sutures, and the employment of drainage-tubes.

Treatment.—Many fistulæ close spontaneously. This can be hoped for only if the opening is quite small, if the general health of the patient is good,

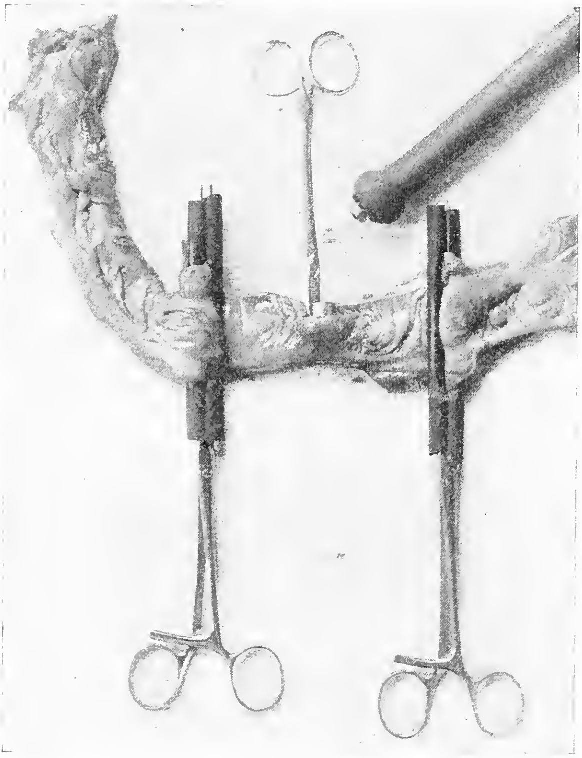


Fig. 452.—Stewart's method of enterostomy.

if the cause has passed away, if the fistula is not lined with mucous membrane, and if there is no spur (spur is shown at *a*, Fig. 451). In most cases of fistula not high up it is well to give nature a chance to effect a cure, and not to be in a hurry to operate. The part is cleansed frequently with peroxid of hydrogen, the patient is kept recumbent, food is given which does not leave much residue, pads of gauze with pressure are applied, and the bowels are kept regular.

If the track is lined with granulations, it may be touched with lunar caustic; if it is lined with mucous membrane, the actual cautery should be

applied; any collection of pus which exists should be drained. If these methods fail, an operation must be performed. The fistula may be sutured by extraperitoneal manipulation (Greig Smith); it may be covered with skin (Dieffenbach); the spur may be removed by means of a clamp; or resection may be performed. In most cases it is best to incise a button of skin around the opening, temporarily suture the fistula, open the peritoneal cavity, deliver the bowel, and suture carefully (Senn's method). In some cases partial exclusion of the fistulous part is necessary, the bowel being divided above the fistula, the end near the fistula sutured, and the other end anastomosed to the bowel below the fistula. In other cases complete exclusion may be performed (page 960).

Ulcer of the Bowel.—In typhoid fever and in dysentery ulceration occurs. An ulcer may be due to tuberculosis or cancer. An ulcer of the duodenum (see below) is due to the same causes as an ulcer of the stomach. An ulcer of the jejunum sometimes develops after the performance of gastro-jejunostomy for gastric ulcer (page 930). *Curling's ulcer* is a chronic ulcer of the duodenum following a burn of the cutaneous surface and due to embolism. An ulcer may heal, and, by causing thickening and constriction, produce chronic intestinal obstruction. It may perforate, causing collapse and subsequent peritonitis.

Peptic Ulcer of the Duodenum.—Occurs usually in that portion of the duodenum which is above the opening of the bile-duct; in other words, only in the region acted on by the acid fluid from the stomach. Reversing the rule in gastric ulceration, duodenal ulceration is more common in men than in women. It may occur at any period of life, from early youth to extreme old age. An indurated chronic ulcer may exist, and this may heal and produce cicatricial stenosis. An acute ulcer is apt to perforate. Just as chronic gastric ulcer may be latent, no symptoms ever being observed, so may chronic duodenal ulcer be latent. Usually there is pain coming on about one hour after taking food, and located in the epigastric or right hypochondriac region. In one-third of the cases there is hematemesis, and sometimes there is blood in the stools. Severe hemorrhage is much rarer than in gastric ulcer. Moynihan * mentions the following complications: severe hemorrhage; perforation; periduodenitis; cancer; and cicatricial contraction involving the bile-duct.

Perforating ulcer is more common than we once thought. Moynihan gathered 49 cases from literature and added 2 of his own. In the great majority of cases perforation of the duodenum cannot be differentiated from perforation of the stomach by a study of the symptoms. In some cases the symptoms resemble appendicitis. In most cases there is a sudden onset of violent abdominal pain, followed by vomiting, shock, rapid pulse, and tenderness of the epigastric or right hypochondriac region. As a rule, after a few hours the patient reacts from shock. Sheild's case got better in four hours and walked some distance to the hospital.† Lucy's case got better a short time after the onset, walked home, and attended to a horse, but then became rapidly worse. The improvement is apparent, not real, and is only temporary. The symptoms quickly become worse, and when they become worse, besides the pain and tenderness and rapid pulse, there will be occasional vomiting,

* Lancet, Dec. 14, 1901. † Lancet, March 29, 1902.

rigidity of the abdomen, usually an elevated or normal temperature, and possibly diminution of the area of liver-dulness.

Treatment.—In chronic ulcer operate if the symptoms are not amended by rigid diet and medication; if severe hemorrhage occurs or if cicatricial contraction interferes with the passage of food through the bowel or bile into the duodenum. Moynihan refers to four cases of chronic ulcer operated upon and all recovered.

In perforation operation is performed, as in gastric ulcer, as soon as possible. In these cases, as in perforated gastric ulcer, I believe operation should be immediate and that we should not wait for a possible reaction from shock. The ulcer is inverted by two rows of silk sutures. Some surgeons do not drain, but I would feel it safer to drain. B. G. A. Moynihan * gathered 49 operations for perforated ulcer with 8 recoveries. Mr. T. Crisp English reports 8 operations for perforation of duodenal ulcers, with 2 recoveries ("Lancet," Nov. 28, 1903). In perforated duodenal ulcer the extravasated fluid is apt to flow into the right iliac region. If an erroneous diagnosis of appendicitis was made, an opening in the right iliac region, by giving vent to this fluid, might for a time confirm the surgeon in error.

Ulcer of the Jejunum after Gastro-enterostomy.—(See page 930.)

Perforated Typhoid Ulcer.—Perforation occurs in about 1 case out of 100. About 70 per cent. of perforations occur in the second, third, or fourth week. Perforation in a typhoid ulcer is usually effected rapidly, a large opening is formed, and a considerable quantity of fecal matter is passed into the peritoneal cavity. In some perforations very little fluid escapes. Severe pain and a nervous chill indicate that perforation is occurring or has occurred. Some maintain that the two above-named symptoms associated with marked leukocytosis indicate that perforation is about to occur, and they call this stage the *preperforative* stage. That distinct symptoms may in some cases point to impending perforation is, I believe, true, and in one case I operated on the conviction and found two areas almost perforated. In most cases, however, I do not believe that there is a distinct preperforative stage, but the perforation exists when the symptoms are first noted. The conviction that perforation was occurring would be strengthened by a progressive increase in the leukocyte count. It is to be remembered, however, that the leukocyte count is increased by sweating, cold bathing, vomiting, hemorrhage, severe diarrhea, or some positive complication. When perforation occurs, violent pain develops. As a rule, there are tenderness, rapid pulse, costal respiration, abdominal rigidity, vomiting, and shock. Usually there is temporary reaction from shock, the subnormal temperature giving way to a normal or to an elevated temperature. The vomiting in some cases becomes stercoraceous. There is constipation and sometimes dulness on percussing the flanks. The face is Hippocratic. The patient may die of the preliminary shock or may react and die subsequently of blood-poisoning. In a few hours after perforation distinct leukocytosis may be observed, but it may never take place at all. Even when leukocytosis arises, it may disappear as peritoneal infection spreads and systemic poisoning deepens. Le Conte points out that rupture of the mesenteric glands simulates intestinal perforation.

Treatment.—Death is practically certain without operation. Operation

* Lancet, Dec. 14, 1901.

should save at least one-fifth of the cases. Operation should be done at once, proper means being adopted to combat shock. In many cases a general anesthetic should not be given, but a local anesthetic should be employed. The incision should be made in the right iliac region and the colon should be first located and then the end of the ileum. By locating the colon we obtain a fixed point from which to begin our search for perforations, and by opening the abdomen in the right iliac region we come down at once onto the perforated gut in the vast majority of cases. When a perforation is found, it should be inverted with two layers of Halsted sutures. It is not wise to excise the ulcer. If the bowel is very badly damaged, resection can be considered, but it is usually wiser to make a temporary artificial anus. After finding a perforation and closing it, examine to see if there are others. Close every perforation, and if a point is found where the thinning of the bowel-wall indicates that perforation is liable to occur, protect this point by inverting the area of ulceration by sutures. Clean the peritoneum by flushing with hot salt solution. Leave the wound open, insert strands of iodoform gauze, and establish tubular suprapubic drainage. Elevate the patient a little in bed and employ continuous proctolysis of salt solution. I have operated eight times for typhoid perforation with three recoveries. Three cases died of shock. In one case the perforation was not found, but was discovered postmortem in the hepatic flexure of the colon, the gall-bladder being responsible for the ulcer of the bowel. One case improved greatly, lived for eight days, developed another perforation, and died of shock. The necropsy showed that the sutured perforation was soundly closed. One case, a young man, brought to me by Dr. Godfrey, was operated upon twenty-four hours after perforation. There was one perforation near the ileum and considerable fecal extravasation. The opening was large and stitches would not hold. The several inches of bowel between the ulcer and the ileocecal valve presented several ulcers almost perforated. The patient was too weak for a resection. After cleansing the abdomen an artificial anus was made proximal to the perforation. The patient recovered and subsequently the anus was successfully abolished by a resection. In another case, that of a young woman, on opening the abdomen a violent appendicitis was found, the appendix being swathed in lymph and gangrenous. The appendix was removed. Search showed a perforation in a loop of gut two feet from the ileocecal valve. There was considerable extravasation. The perforation was closed. The peritoneum was cleansed, drainage was inserted, and the patient recovered. Cultures from the appendix and from the peritoneal cavity showed only the colon bacillus. In a third case, that of a young woman, impending perforation was diagnosticated by Dr. Kalteyer because of pain, tenderness, some rigidity, and definite and increasing leukocytosis. Two ulcers almost, but not quite, perforated were found. They were covered over by the use of inversion sutures, the wound was closed without drainage, and recovery followed. Culture from the peritoneal cavity was negative. These three successful cases were operated upon in the Jefferson College Hospital.

Primary Intestinal Tuberculosis.—According to Kocher, there are 80 cases on record. He reported 29 cases to the Swiss Medical Congress in 1892. Primary tuberculosis is very rare, whereas secondary tuberculosis is common. The exact propriety of rigidly regarding such cases as *primary*

is doubtful. Kocher's cases came from tuberculous stock, and suffered in infancy from enlarged glands, pleurisy, or bronchitis, and that surgeon says that, in all probability, there had for some time been somewhere in the body a latent tuberculous focus, and from this focus came the bacteria which attacked the intestine. Intestinal tuberculosis, in the victims of phthisis, begins with the formation of multiple ulcers, due to swallowing tuberculous sputum. Primary intestinal tuberculosis usually begins as one ulcer or several, or even many ulcers in the ileum or perhaps in the cecum. These ulcers tend to heal and form strictures. Occasionally, in primary tuberculosis there is enormous tumor-like thickening of the cecum. This is *hyperplastic tuberculosis*, the *conglomerate tuberculosis* of Mayo. The symptoms, as a rule, are slight, attacks of pain occurring now and then, and stricture gradually developing. The urine shows the diazo reaction (Kocher).

Treatment.—In the first stage the proper treatment is excision of ulcerated areas, possibly excision of the cecum. Later, if stricture is causing chronic obstruction, an operation may be performed to give relief. Laparotomy, careful separation of adhesions which are not fused with the gut, and the introduction of iodoform may prove of value.

Malignant Tumor of the Intestine.—*Sarcoma* is very rare, but does sometimes arise, particularly in young persons, and it enlarges very rapidly. It is most prone to attack the large intestine. Jopson and White * report 1 case and also collect 22 others. The mesenteric glands frequently enlarge. *Cancer* is not uncommon, attacking especially the middle aged. It is most common in the neighborhood of the ileocecal valve and in the sigmoid flexure. Ewald collected 1148 cases of cancer of the intestine. In 64 cases the cecum was involved; in 24 cases the ileum was involved. It produces pain at the seat of growth, and after a time constipation, or constipation alternating with diarrhea, and finally intestinal obstruction. In some cases the symptoms appear suddenly, acute obstruction taking place or intussusception occurring. It is usually possible to palpate the tumor, which is hard and immovable. The patient wastes rapidly and is apt occasionally to pass blood at stool. The growth does not enlarge very rapidly and glands are not involved early. In some cases the supraclavicular glands enlarge. In more than one-half of the cases which die of intestinal cancer there is no lymphatic infection.†

Treatment.—Early in the case exploratory laparotomy should be performed, followed, if possible, by excision with end-to-end or side-to-side approximation. This is done for either cancer or sarcoma. It may be possible to remove enlarged glands. In cancer of the cecum extirpate the cecum and implant the end of the ileum into the side of the colon (Wm. J. Mayo). If excision is impossible, the growth should be side-tracked by performing lateral anastomosis. In advanced cancer of the large bowel, if resection is impossible, make an artificial anus above the tumor (cancer of rectum, page 1021).

Appendicitis.—Appendicitis, which is an inflammation of the vermiform appendix of the cecum, is almost invariably the primary lesion of all of those various conditions known as typhlitis, perityphlitis, paratyphlitis, etc.—terms which no longer imply pathological entities, and are in most instances well relegated to obscurity. It was recognized by some observers many years

* Am. Jour. Med. Sciences, Dec., 1901.
† Wm. J. Mayo, Jour. Am. Med. Assoc., Oct. 19, 1901.

ago that such a disease existed, but the majority of the profession did not grasp the fact. In 1750 Mestevier, of France, reported a case of perforative appendicitis with peritonitis.* In 1812 a perforated appendix was shown to the Medico-Chirurgical Society of London, and in 1835 Southam reported an appendiceal abscess (Manley). In 1849 Hancock reported an appendiceal abscess. In 1827 Dr. L. Méllier described appendicitis, and named among its symptoms fixed pain in the right iliac fossa and colic. This brilliant investigator was years ahead of his contemporaries. He reported cases of undoubted appendicitis verified by autopsy, described gangrene, perforation, associated peritonitis, and appendiceal concretions. His original article, Manley tells us, is in the "Journal of Medicine, Surgery, and Pharmacy" for 1827, second series, 110.† Méllier said: "If it were possible to establish with certainty the diagnosis of this affection, we could see the possibility of curing the patient by operation. We shall perhaps some day arrive at this result."‡ In spite of Méllier's writings, the profession adhered for half a century to the view of Dupuytren, put forth in 1833, that abscesses in the iliac region take origin from the cecum and not from the appendix. Dr. Reginald Fitz, of Boston, in 1886 persuaded the world that the appendix is the real seat of most inflammations in the right iliac fossa. The appendix is a long and narrow diverticulum (musculomembranous in structure), which comes from the posterior and internal part of the head of the colon, and which has no physiological function (in herbivora and rodents it is a functionally active organ). The structure of the appendix is similar to the structure of the colon, except that the muscular structure is ill developed and trivial in amount. Lockwood points out that there is an extensive lymph system in the appendix, and that the submucous and subperitoneal tissues communicate by numerous gaps in the muscles.§ This structure has a poor blood-supply, and in consequence gangrene occurs from rather trivial causes. It is supplied by a branch from the superior mesenteric artery. In women there is sometimes an additional supply by a vessel running in the appendiculo-ovarian ligament. The nerves are derived from the superior mesenteric plexus. The appendix averages about four and a half inches in length, but varies in size between the limits of one-third of an inch and a little over 9 inches. In 641 autopsies the longest appendix was $9\frac{1}{3}$ inches and the shortest was one-third of an inch (Monks and Blake). Its diameter is, as a rule, about equal to that of a No. 9 English bougie; its canal is narrow and is partly closed by the valve of Gerlach (Talamon). The appendix enters the cecum at its posterior internal part, which is usually the seat of the most intense pain in inflammation, and corresponds to a point on the surface two inches from the anterior superior spine of the ilium, on a line drawn from the umbilicus to the iliac spine, which is known as "*McBurney's point.*" The free part of the appendix in one-third of all persons is in relation with the posterior surface of the cecum; in almost one-third of all persons it is fixed in the iliac fossa, so that if perforation occurs, the contents will be voided in the retroperitoneal tissue (iliac abscess). In some cases it is external to the cecum; in some it passes downward, and in some inward. It is important to remember that the appen-

* Jour. Méd. et Chir., 1760. † Thomas H. Manley, Med. Record, July 19, 1902.
‡ See R. J. Lee Morrill's article in the Amer. Med.-Surg. Bull., Dec. 19, 1896.
§ Brit. Med. Jour., Jan. 27, 1900.

dix may be met with in the most unexpected situations. When the ascending colon is displaced, the diverticulum may be upon the left side. It is not unusual to find its tip in the middle line, up toward or adherent to the gall-bladder, or in the pelvis. In about two-thirds of all cases the appendix is completely covered with peritoneum; in one-third of all cases it is in contact, in some part of its length, with cellular tissue (Talamon). Byron Robinson has called attention to the fact that the appendix is frequently in contact with the psoas muscle in men, and may be bruised by this muscle. In 10,000 autopsies the appendix is said to have been absent five times. In most cases where surgeons have been unable to find the appendix it was not absent, but was covered with peritoneum. Occasionally the appendix is found in a hernial sac.

Etiology and Pathology.—Appendicitis is very rare in infants. I operated unsuccessfully on a male two years of age for gangrenous appendicitis. Savage operated unsuccessfully on a baby sixty-one days, and Weiss operated unsuccessfully on a child twenty months old.* J. P. Crozer Griffith † has collected 15 cases in children under two years of age. One of these patients was three months of age. Nine of the 15 were operated upon, with 7 recoveries. In 4 of the cases the appendix was in the scrotum. In 2 cases a diagnosis of intussusception was made. Appendicitis is common at any period beyond childhood, being more frequent in young and middle-aged people than in the aged. It is about four times as common in males as in females. It is more common in summer than in other seasons, and in warm countries than in cold or temperate climes. Appendicitis is a bacterial disease. It is produced occasionally by pus cocci, but most commonly by the action of the bacterium coli commune of Escherich. The colon bacilli, which normally inhabit the appendix, are harmless when the appendix is healthy, but become active for harm when the diverticulum is bruised, obstructed, irritated by the presence of uric acid, congested because of chilling of the cutaneous surface of the body, or distended by the ingress of colonic fluid (C. Van Zwulenburg in "Annals of Surgery," March, 1905). It seems probable that flatulent distention of the colon may be responsible for forcing fecal matter in quantity into the appendix and may lead to plugging of the opening (Rubin, in "Jour. Am. Med. Assoc.," vol. xliii, No. 18). When non-traumatic inflammation occurs, swelling of the mucous membrane occludes the opening into the colon, and the lumen of the appendix dilates and fills up and becomes distended with a thick mucopurulent fluid. Ulcers sometimes form, which may only involve the mucous membrane, may pass deeply into the coats, or may even perforate. Dieulafoy ‡ maintains forcefully that appendicitis is due *always* to the conversion of the appendix into a *closed* cavity, but cases are met with which disprove this assertion. Various conditions may bring about this transformation. Partial obstruction may be caused by calculi, which are composed of stercoral material and hordes of bacteria mixed with salts of lime and magnesia. These calculi are not formed in the colon but are formed in the appendix. The theory that concretions form in the colon and are forced into the appendix by peristalsis has been very largely abandoned. Dieulafoy speaks of the condition as *appendicular lithiasis*, and says it has a tendency to run in family

* Manley, in Med. Record, July 9, 1902.
† University of Penna. Med. Bull., Oct., 1902.
‡ Progrès médicale, No. 11, 1896.

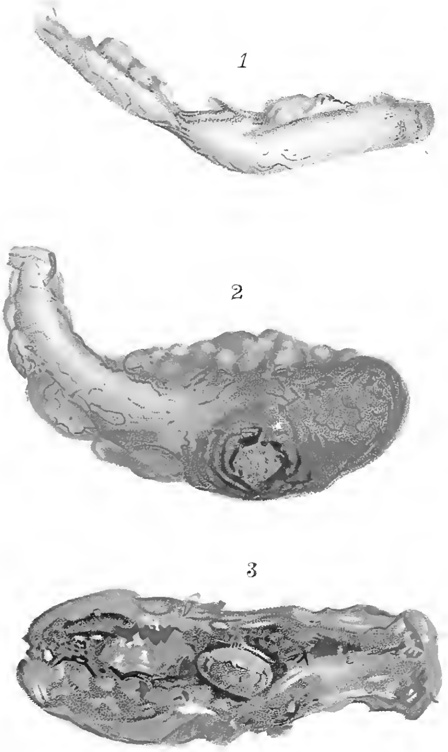
lines, and has a kinship with gout and rheumatism. Obstruction may be caused by local infection of a catarrhal area, by the formation of a fibrous stricture, or by several causes acting in unison. The presence of a concretion is always dangerous. It is frequently associated with ulceration, either as cause or effect. It is a mass of virulent bacteria. It may lead to perforation or gangrene. Talamon taught that the appendix resents the presence of the concretion, reflex contraction of the muscular coat taking place, which is accompanied by violent pain (*appendicular colic*). The muscular structure is so rudimentary that it does not seem probable that attempts at contraction, even should they arise, would produce violent pain and distant symptoms. Pozzi believes that appendicular colic may be caused by torsion or bending of the appendix or malposition of the diverticulum, and holds that pain may arise when there is no lesion in the appendix and no inflammation of the peritoneum or pericecal structures.* What is called appendicular colic is really inflammation of the appendix without involvement of the peritoneum. The term appendicular colic has led to much injudicious conservatism, and, as Lockwood shows, if an appendix is removed from an individual who suffers from attacks of appendicular colic, it will usually be found that the diverticulum is inflamed or the lumen contains a concretion. Foreign bodies, such as pins, fish-bones, nails, buttons, date-stones, cherry-stones, and grape-seeds may enter the appendix, but they do so far less often than is generally supposed, most alleged grape-seeds from the appendix being fecal concretions. Fitz found concretions in 15 cases out of 300. Ranvier collected the records of 459 postmortems, and found reported 179 fecal concretions and 16 foreign bodies. Appendicitis due to a foreign body, such as a grape-seed or a pin, is known as *traumatic;* appendicitis in which a concretion is the assumed cause is known as *stercoral.* A foreign body may produce instant perforation. If impaction of a foreign body or concretion occurs, the orifice of the appendix is closed, the circulation is soon cut off, the secretions are retained, the coats become congested, the diverticulum enlarges enormously, microbes multiply with great rapidity, and the wall of the congested appendix inflames and may become gangrenous or ulcerated, and is finally perforated. Interference with the blood-supply of the appendix will predispose to appendicitis. This may be brought about by twists, bruises, adhesions, concretions, pressure, or bands; and the psoas muscle may play a part in the production of these conditions. In women appendicitis is occasionally secondary to tubo-ovarian disease. Appendicitis is rarer in women than in men, probably because in many females the appendix has a better blood-supply than in males, the additional supply coming through the folds of the appendiculo-ovarian ligament. In women disease of the uterus or adnexa frequently precedes or actually causes appendicitis. Catarrhal conditions of the intestine, habitual constipation, and indigestion with flatulence predispose to appendicitis. In fact, in a great many cases there has been a more or less prolonged history of diarrhea or constipation and flatulent indigestion before the development of acute appendicitis. An acute attack of appendicitis may arise after the eating of a large and indigestible meal, especially if such a meal was taken late at night. Bolting the food and eating large meals at irregular hours predispose. It seems probable that catarrhal appendicitis may result

* Progrès médicale, No. 19, 1896.

from extension of a catarrh of the colon, and may also in rare cases arise from external traumatism. In most cases, however, in which appendicitis seems to be produced by a blow, the injury simply "awakened a sleeping dog" and stirred into acute inflammation an appendix already diseased. If before perforation the appendix adheres to the cellular tissue behind the cecum, cellulitis or abscess without peritonitis may result. When appendicitis goes on to perforation, there is always some peritonitis; but if the steps to perforation are gradual, and if the causative organism is the colon bacillus, the peritonitis may be local, and will sometimes, by formation of adhesions, make a barrier between the appendix and the peritoneal cavity before perforation occurs. When perforation takes place suddenly, diffused septic peritonitis is inevitable. When the causative organism is the streptococcus, general peritonitis is very apt to arise. Peritonitis may arise without perforation by contiguity of structure or by migration of bacteria through the congested walls of an obstructed appendix. In some cases perforation takes place into the peritoneal cavity, but pus is circumscribed by matting together of the intestines with plastic exudate. The appendix may become gangrenous very rapidly or after some time. A case of appendicitis in which gangrene and perforation come on very quickly is spoken of as *fulminating appendicitis*. In some cases, if the perforation is very small and the appendix is swathed in lymph, or if perforation does not occur, the inflammation may subside. Perforation rarely occurs from liquid pressure or from the pressure of a concretion; it is generally due to ulceration produced by the action of micro-organisms. Appendicitis which subsides may at any time recur, and the life of such a patient is under constant menace. An enormous number of people have had appendicitis. Toft recorded 500 autopsies, and in 36 per cent. of them there were positive signs of past attacks. The disease is occasionally unsuspected during life. These facts prove that the disease may subside without the aid of surgery.

Forms of Appendicitis.—In what is known as *appendicular colic* the appendix is temporarily obstructed because of transitory inflammatory swelling of the mucous membrane of the outlet, and the stercoral contents are retained in the diverticulum. The peritoneal covering is not involved in the inflammation. This condition is called by Fergusson "*constipation of the appendix*." If not relieved, it will eventuate in appendicitis with involvement of the peritoneum. It is an unfortunate term, sometimes used as an excuse for avoiding operation. In such cases a concretion is frequently or usually present.

Simple parietal or catarrhal appendicitis is not limited to the mucous membrane; hence the term *catarrhal* is not strictly correct. The vessels of the appendix are distended with blood, the lumen at the intestinal end becomes partially or completely obstructed, the epithelium desquamates from numerous glands, the mucosa ulcerates, and the lumen of the appendix becomes filled with a mixture of mucus, bacteria, and portions of organic matter. Bacteria enter the lymph-spaces of the wall of the appendix, and pass rapidly from the submucous to the subperitoneal tissues. Within forty-eight hours after the mucous coat begins to inflame the peritoneal coat will probably be involved. This inflammation may undergo resolution and the patient get well or a wait for cure may result disastrously. The appendix may thicken and ulceration take place. Suppuration or gangrene may occur, perforation may take place, or pyemia, with abscess of the liver, may arise. The acute condition may pass into



Various forms of appendicitis (from drawings by Dr. M. H. Richardson): 1. Obstruction from stenosis of appendix. 2. Dilatation of distal end of appendix; perforation by a fecal concretion. 3. Gangrene of nearly the whole of the appendix; fecal concretion in lumen.

chronic appendicitis, or ulcerations of the mucosa may remain; the mucous crypts may be filled with bacteria; a concretion may exist; cicatricial contractions may occur; in any of these conditions the patient is in danger of a fresh attack at any time. In a catarrhal inflammation secondary to catarrh of the colon the case may be chronic from the beginning. If the lumen of the appendix is gradually and completely obliterated, the condition is denominated *obliterative appendicitis* (Senn). This progressive obliteration may result from repeated attacks of inflammation, or may be simply a degenerative change. *Recurrent appendicitis*, it was once said, may be due to inordinate size of the mouth of the appendix, making of this diverticulum a drag-net for foreign bodies; but we now know that it is more probably due to smallness of the opening, so that it quickly closes from slight swelling and converts the appendix into a closed vase filled with septic material. *Suppurative appendicitis* is due to purulent infiltration of the walls. Pus in the lumen is not purulent appendicitis. Pus may form about the appendix, a condition known as *appendiceal* or *appendicular abscess*. *Gangrenous appendicitis* is a moist or septic gangrene, due to interference with the circulation and to tissue-destruction by the action of micro-organisms. Perforations occur, and they are often multiple. The entire appendix may slough off. Interference with circulation may be caused by an obstruction, by a bend or twist or bruise of the appendix, or by the action of virulent organisms on an appendix whose tissue-resistance is lowered by injury or disease. In gangrenous cases the vessels of the meso-appendix are usually obstructed by thrombi or the changes of arteritis (Van Cott). In rare instances appendicitis is due to tuberculous ulceration, in other cases to typhoid ulceration, and genuine appendicitis may arise during typhoid fever.

Fowler suggests the following classification of cases of appendicitis: (1) endo-appendicitis; (2) parietal appendicitis; (3) peri-appendicitis; (4) para-appendicitis.

As a matter of fact, appendicitis is always one disease, which varies in intensity, and it is useless to divide it into a great number of symptomatic groups.

Symptoms and Signs.—In what is known as *appendicular colic* the patient suffers from disorder of digestion and occasionally has a brief attack of abdominal pain associated with trivial and temporary tenderness in the right iliac fossa. The colicky pain is about the umbilicus and right iliac fossa; there is often nausea and usually constipation. This condition, if not soon relieved, is followed by the evidences of peritoneal inflammation. The symptoms of genuine appendicitis are as follows: In some cases the disease seems to begin suddenly, but in most of the cases there are noted for a few hours or even for a day or two distinct *premonitory symptoms*, among which are constipation and diarrhea, flatulence, nausea, anorexia, dyspepsia, coated tongue, weakness, general gastro-intestinal uneasiness, colicky pain about the umbilicus, and the development of tenderness, a sense of weight, soreness, or actual pain in the right iliac fossa. The acute symptoms suddenly appear after the premonitory symptoms have lasted a variable time, and the acute symptoms very frequently appear in the early hours of the morning. The first definite symptom is severe colicky pain. The tongue is coated and usually dry. Great thirst is often complained of. The face is expressive of pain, or later, in a severe case, becomes Hippocratic. The posture assumed for greater ease is one of recumbency with the right thigh and knee or both thighs and knees

partly flexed. Respirations in acute appendicitis are shallow and thoracic. The development of acute pain is usually the most prominent symptom. The pain is at first colicky and located about the umbilicus or through the abdomen in general, this distant, primary, or generalized pain, according to Treves, corresponding to the distribution of the superior mesenteric plexus. This primary pain may subside if the appendix succeeds in emptying its contents into the colon, but it may also subside if the appendix becomes gangrenous or ruptures (Murphy). Usually, in from twelve to thirty-six hours the pain becomes localized in the right iliac fossa, and associated with tenderness and hyperesthesia of the skin—in other words, true inflammatory pain develops. It is due to peritoneal inflammation. The usual location of the pain in the right iliac fossa depends on the fact that the appendix is usually placed in that region. Occasionally, when the appendix crosses the belly, the pain is located on the left side, and occasionally, for like reasons, in the gall-bladder region, the right loin, or the pelvis. If the pain of appendicitis is violent, the patient presents some evidences of shock. Nausea is the rule in appendicitis; vomiting usually occurs early—about three or four hours after the beginning of pain. In children vomiting is often violent and persistent, but in adults, after the early hours of the attack, vomiting occurs, as a rule, occasionally or not at all, although nausea is complained of. Early vomiting is a reflex symptom due to distention of the appendix (Murphy). If vomiting persists, it points to peritonitis, to pus-formation, or to intestinal obstruction unless it results from the administration of morphin. There is usually constipation in acute appendicitis, although diarrhea occasionally occurs. In appendicitis there is always some elevation of temperature, although it may be very slight and of brief duration. The fever is not ushered in by a chill, but the temperature mounts in the course of a few hours to 102° or 103° F. or even higher. The fever does not begin until several hours or a number of hours after the onset of pain. In a very mild case the temperature remains elevated for a day or two and then falls to normal. In severe cases it is apt to remain elevated for a longer period, but it is always to be borne in mind that in very grave appendicitis the surgeon may find very little elevation of temperature, no elevation, or actually a subnormal temperature. In gangrenous cases, and in cases in which a large perforation suddenly forms, and when general peritonitis develops, there is usually, for a time at least, a subnormal temperature. A *sudden* drop of temperature indicates, as a rule, a calamity, particularly gangrene of the mucosa of the appendix, which prevents absorption (Murphy) or perforation of the appendix. Leukocytosis is usually present (see Diagnosis). The pulse in appendicitis is in most cases rapid. A very rapid pulse (over 110) is significant, usually, of a severe case, and the auguries are especially ominous if the pulse is rapid but the temperature is normal or subnormal. Occasionally, however, a slow pulse exists, even in the worst cases.

Examination of the abdomen discovers, early in the case, general abdominal rigidity; but usually in the course of twenty-four hours or more the general rigidity passes away, the abdomen distends more or less, and rigidity of the lower half of the right belly becomes evident and persists. If general peritonitis begins early, general abdominal rigidity does not abate or pass away. If general peritonitis begins later, general abdominal rigidity, which was pres-

ent at first but which passed away, returns. Rigidity may not exist in the very beginning of appendicitis, in a case in which the appendix is retrocecal or pelvic, in some abscess cases, or in a case with relaxed belly walls.

A symptom almost invariably present in appendicitis is tenderness. In some cases the tenderness is diffuse; in most it is localized, or at least most acute, in the right iliac fossa. The point where tenderness is usually most acute is a spot about 2 inches internal to the anterior superior spine of the ilium, on a line drawn from that bony point to the umbilicus. This is known as "*McBurney's point*," and overlies the usual point of origin of the appendix. In some cases, however, the greatest point of tenderness is nearer the gall-bladder; in others in the loin; in others toward the umbilicus, in the mid-line, or on the opposite side; in others in the rectum. The seat of greatest tenderness depends on the situation of the appendix, and it is usually at McBurney's point, because this usually overlies the origin of the appendix. The lesson is that in appendicitis there is a point of tenderness or of greatest tenderness in a region which the appendix could occupy. If tenderness exists on the right side and then develops in the left side, severe spreading peritonitis usually exists (W. Meyer). When the appendix becomes gangrenous, local tenderness may for a time disappear, because the peritoneum of the involved region has become anesthetic; later, however, it returns, spreads, and may become general. In view of the fact that tenderness in the right iliac fossa is often demonstrable in tubal and ovarian disease, the sign in males "is of greater significance than in females" (A. H. Tubby, on "Appendicitis," Medical Monograph Series). Pressure upon the left side will, in some cases, cause pain in the right iliac region. When rigidity abates or disappears, the case may go on to cure, but sometimes a mass becomes evident in the right iliac fossa. The mass, of variable shape, is at first hard, and if of any considerable size, is dull on percussion. In some cases, when no mass is palpable through the abdominal wall, rectal examination detects one. This mass may be agglutinated bowel and omentum or a collection of coagulated inflammatory exudate. It may gradually disappear or an abscess may form. The evidences of general peritonitis are: great distention because of intestinal paresis, general abdominal tenderness, rectal tenderness, very rapid pulse, hiccough, persistent vomiting which may become regurgitation, and, as Meyer points out, percussion dulness over the right iliac region or entire lower abdomen.

In some cases the symptoms, at first trivial, become grave. In some all the symptoms are violent from the beginning, the attack tends to linger, and is followed by persistent soreness of the appendix and harassing digestive disturbances. Any case of appendicitis may become suddenly desperately grave because of perforation or gangrene, and in any case general peritonitis may develop. After sudden perforation or rapid gangrene the temperature falls, hiccough begins, abdominal distention, pain, and tenderness become marked and general, and the pulse becomes very rapid. In some cases these grave symptoms are present almost from the start (fulminating cases). A sudden perforation produces collapse, and, if reaction takes place, general peritonitis arises. Peritonitis, be it remembered, may arise without either perforation or gangrene. If pus forms, it may be unlimited by adhesion. In such cases there is the rapid onset of fatal peritonitis and septicemia. Pus may be limited by adhesions and be practically extraperitoneal. In

such a case a lump is felt in the right iliac region, but dusky discoloration and edema of skin very seldom exist. The surgeon does not wait for fluctuation before he makes a diagnosis. In an abscess case there are usually irregular fever and sweating, but rigors do not occur. Hawkins says we should always suspect pus if the symptoms continue after the sixth day, and particularly when the symptoms abate and suddenly increase between the seventh and tenth days. A limited collection of pus may be liberated into the peritoneal cavity by rupture of the abscess-wall. Such a rupture may be caused by pressure or muscular effort; rupture is followed at once by shock and later by diffused peritonitis. An abscess may rupture externally or into the vagina, intestinal tract, or bladder. It is desirable, if possible, to locate the situation of the appendix, and this is usually determined by locating the seat of swelling and of greatest tenderness. The surgeon should not lose sight of the fact that the appendix may be found in the most unexpected situations. In every case a rectal or vaginal examination should be made, in order to detect swelling and tenderness, and thus determine if the inflammation took origin in or has come to involve the pelvic region. Pain at the end of micturition points to involvement of the vesical peritoneum.* In cases where there is not *localized* swelling and is not local tenderness,—for instance, in gangrenous or perforative appendicitis with general peritonitis,—"diagnostic localization" is impossible (Van Hook).

Terminations and Prognosis.—Acute appendicitis may terminate in death, in complete recovery, or in a condition of lowered vitality during the existence of which acute attacks are almost certain to occur. Sometimes after and sometimes without an antecedent acute attack the patient develops persistent soreness and tenderness in the right iliac region. Between the attacks of recurrent appendicitis there may be soreness, tenderness, and gastro-intestinal disturbance, or there may be no evident trouble whatever; yet, even in the latter case, there may be an ulcer or ulcers of the mucous lining. If a patient has once had appendicitis, he will always be liable to suffer from another attack if the appendix has not been removed. The liability becomes almost a certainty if the intestinal end of the appendix is narrowed or if the lumen is obstructed at any point, if a concretion exists, or if there is an area of ulceration or of desquamating epithelium. After an attack the appendix may remain enlarged and tender; exercise or indiscretion in diet may cause it to become tender or the patient may have occasional attacks of colicky pain. If any of the above conditions exist, another attack may be confidently anticipated if operation is not performed. In such cases the appendix can usually be palpated. The method of palpation proposed by Robert T. Morris is very useful.† It is applied as follows:

The surgeon stands to the right of the patient and uses three fingers of the right hand to feel with and three fingers of the left hand to press with. Morris insists that no muscular effort should be used by the hand which feels. The feeling fingers are pressed by the other fingers beneath the margin of the right rectus muscle on a level with the umbilicus, and are drawn toward the patient's right side, and the colon will be felt to roll under the fingers. The process is repeated several times until the end of the cecum is reached.

* Van Hook, in Jour. Am. Med. Assoc., Feb. 20, 1897.
† See Medical Record, Sept. 17, 1898.

The appendix is sought for by rolling the cecum from side to side with the finger-tips, and working toward the proximal end of the appendix.*

Adhesions may form as a result of appendicitis, general peritonitis may arise, the appendix may slough or become perforated, or abscess may ensue upon local peritonitis. Lymphangitis of the appendix may accompany, and septic lymphangitis or phlebitis and secondary hepatic and lymphatic infections may follow, appendicitis. They are thought to be most common after mild attacks of appendicitis. The secondary *lymphatic* and *hepatic infections* are of the greatest importance. There may be abscess of the liver, subphrenic abscess, or retroperitoneal lymphangitis.

A subphrenic abscess may result from infection carried from the appendix by the lymphatics, from pus ascending along the posterior cellular spaces, or by direct invasion from the peritoneal cavity (John C. Munro, in "Annals of Surg.," Nov., 1905); such an abscess is usually on the right side but may be upon the left.

Lymphangitis is the rule in appendicitis, and when we open the abdomen, there is usually evidence of it in the lymph-glands of the mesentery, and in children particularly these glands are apt to be enlarged. One lymph path from the appendix is through the ileocecal glands, another is posterior to the cecum and retroperitoneal, and the latter reaches the liver and diaphragm (Munro). In lymphatic infection an abscess may form anywhere in the course of the lymphatics. Abscess of the liver usually results from portal invasion but may result from lymphatic infection.

Among other possible consequences of appendicitis may be mentioned pyemia, empyema, inflammation of the parotid gland, and thrombosis of the right iliac vein. A positive prognosis of any case of appendicitis is an absolute impossibility. The future of every case is cloudy with uncertainty, and the most that can be attained in the field of prediction is a scientific guess of more or less probability. All surgeons have seen apparently hopeless cases recover, and have observed cases with the most trivial symptoms grow progressively worse or suddenly develop a fatal complication. Further, after one attack other attacks are very apt to arise. The medical man who estimates that 80 or 90 per cent. of cases get well without operation has probably dealt with many catarrhal cases, and he certainly is optimistic as to freedom from future attacks, because, as stated before, recovery from an attack does not of necessity mean freedom from the disease. In appendicitis there may be delusive evidences of improvement; for instance, the abatement of pain and the lessening of fever, being regarded by the patient himself as indubitable signs of improvement, may in reality be indicative of gangrene. In spite of the previously mentioned difficulties and obscurities we can in the majority of cases decide with a reasonable probability of accuracy whether or not the patient is becoming worse. In a delusive improvement some signs and symptoms improve, but all do not; and in endeavoring to form a prognosis, *all* the signs and symptoms must be noted and weighed: pain, tenderness, rigidity, distention, nausea and vomiting, delirium, intestinal obstruction, shock, the temperature, the rapidity of the pulse, the blood examination, etc. If *all* these elements, not only some of them, point to improvement, we may be reasonably confident that improvement is really taking

* Robert T. Morris, in Medical Record, Sept. 17, 1898.

place. If only some of them point to improvement, we will in many cases be altogether uncertain as to the significance of the change.

Diagnosis.—The diagnosis is not invariably certain, as many light-hearted operators seem to believe. It is frequently far from easy and is sometimes altogether impossible without exploratory operation. Sonnenburg maintains that we can diagnosticate the pathological condition of the inflamed appendix. Personally, I am unable to do this with any certainty, although I always try, and am often right and just as often wrong.

In attempting to make a diagnosis, besides the ordinary examination of the abdomen a rectal or vaginal examination should be made, associated in many cases with bimanual palpation. If an appendix is enlarged and an individual has a thin abdomen which is not rigid, it is often possible to palpate the appendix. Sometimes it can be felt after the administration of ether when it could not be detected before. In an acute case forcible or prolonged palpation is always unjustifiable, as it may force an ulcer to perforate, or may rupture an abscess, and the information gained is not of sufficient importance to justify the risk. In a chronic case information of great value may be obtained and there is no real risk in the maneuver. I am persuaded John B. Murphy is correct in attaching the greatest possible importance to the order in which symptoms appear. Pain *precedes* nausea and vomiting, elevated temperature, and abdominal tenderness. If fever precedes pain, the condition is not appendicitis. If vomiting precedes pain, the condition is probably not appendicitis.

The disease may be confused with a number of different conditions. It sometimes is confused with typhoid fever; in fact, an early typhoid fever associated with marked abdominal pain gives a picture very similar to that furnished by appendicitis.

In typhoid fever the temperature is usually distinctly higher than that commonly encountered in appendicitis. Maurice H. Richardson* tells us that in every case in which typhoid is suspected, operation is not justifiable on the hypothesis of existing appendicitis, unless there are local pain and localized tenderness in the appendix region, associated with definite muscular resistance or distinct rigidity; and that operation should be postponed in a case in which the constitutional signs are severe and the local signs are difficult to detect; but when there are pain, tenderness, and rigidity with or without distention, operation must be performed, even when one recognizes the possibility of the existence of typhoid fever. Richardson lays down the following rule: Soft abdomen plus high temperature suggests typhoid, even if there are pain and tenderness. In appendicitis there is usually leukocytosis; in typhoid leukocytosis is absent, except when perforation is imminent or has occurred, or when some other complication exists. I have seen the operation performed twice for supposed appendicitis when the condition in each case was found to be early typhoid fever.

Acute intestinal obstruction is sometimes confused with acute appendicitis, and the mistake is particularly likely to occur if the obstruction is due to intussusception. In acute obstruction, as in appendicitis, the pain is first appreciated about the umbilicus; but in acute obstruction it remains in that region, does not pass to and localize itself in the right iliac fossa,

* Boston Med. and Surg. Jour., Jan. 9, 1902.

and is not associated with tenderness of the right iliac fossa. In obstruction the vomiting is persistent; in appendicitis, except in the beginning, it is usually trivial and often absent, although in children it may be violent and persistent. In acute obstruction shock is much more pronounced than in appendicitis, and early and great distention of the abdomen is noted. The temperature in obstruction is usually subnormal; while in appendicitis, at least in the majority of cases, the temperature is distinctly elevated. Further, in acute intestinal obstruction the constipation is absolute, except in cases of intussusception. In children, intussusception is capable of particularly confusing the diagnosis, because, after the first day, it is by no means unusual to have distinct fever in this condition, and occasionally a tumor-like mass is found in the right iliac fossa; but in intussusception the tumor does not remain fixed, but alters its position; it is movable; and the patient usually suffers from tenesmus and the passage of bloody mucus. One should bear in mind that in acute appendicitis associated with septic peritonitis acute obstruction may exist; and that the diagnosis of obstruction may be made without recognizing the appendicitis.

Lesions of the kidney are sometimes mistaken for appendicitis, but in renal colic the pain runs into the groin and testicle of that side, and occasionally passes down the front of the thigh or into the rectum; and if any tenderness exists, it is found in the loin or in the groin, rather than in the right iliac fossa. Besides this, there are other symptoms of kidney trouble. The urine may contain blood or pus, and there may be a history of difficult or of frequent urination, though one should bear in mind that in appendicitis with inflammation of the vesical peritoneum there may also be a record of urinary difficulties. An x-ray picture may exhibit a calculus in the ureter or kidney, and a movable kidney is distinctly palpable. In ordinary renal colic there is vomiting in the beginning, just as in the beginning of appendicitis. In movable kidney the vomiting is often more violent and prolonged than is common in appendicitis. Movable kidney and appendicitis may exist coincidentally.

Gall-bladder difficulties, too, may be confounded with appendicitis. I have operated upon a case of cholecystitis under the supposition that it was one of appendicitis; and upon a case of appendicitis with the appendix adherent to the gall-bladder, in the belief that the condition was cholecystitis. In an inflammation of the gall-bladder, with a distended gall-bladder hanging low down, and with muscular rigidity, the distinction is always difficult and sometimes impossible. In ordinary gall-stone colic the condition is usually sudden in onset; it is characterized by pain in the epigastric region, passing toward the shoulder-blade and the shoulder, the pain being most acute and becoming more or less localized in the region of the gall-bladder; and there is always tenderness over the gall-bladder region. In gall-bladder colic the vomiting is violent and continuous.

The perforation of a gastric ulcer or of a duodenal ulcer may be diagnosticated as appendicitis. In perforation of a gastric ulcer there is usually a history of previous difficulty with the stomach, though this is not always the case. The onset of perforation is sudden, with much greater shock than is characteristic of the onset of appendicitis. The pain is violent and the pain and rigidity and tenderness are in the epigastric region.

Among other conditions that may be confused with appendicitis may be mentioned malignant disease of the cecum, tuberculosis of the cecum, acute tuberculous peritonitis, twisting of the pedicle of an ovarian tumor, tubal disease, extra-uterine pregnancy, membranous colitis, perinephric abscess, tuberculous abscess of the loin or of the groin, and abscess from hip-joint disease.

Pneumonia of the right base and pleurisy may cause abdominal pain and be mistaken for appendicitis. There may even be superficial tenderness in the abdomen, but deep pressure is well tolerated (Donald W. Hood, "Brit. Med. Jour.," Dec. 30, 1905). There may be abdominal rigidity. The abdominal pain seldom persists for more than a few hours. It is intensified by deep respiration and is accompanied by high fever. As Hood says, whenever a patient suffers from vomiting, abdominal pain, and high fever examine the chest. In young children pneumonia is particularly apt to cause abdominal pain and rigidity. Beyond a doubt more than one abdomen has been opened for supposed appendicitis when the real condition was pneumonia.

In reaching a diagnosis in doubtful cases of appendicitis I believe that the blood-count is often of service. It is, of course, not to be maintained that the diagnosis of appendicitis may be made by counting the blood; but the blood-count may furnish evidence that, when added to the other signs and symptoms, may be of great importance. In nearly every case of appendicitis the hemoglobin is diminished by at least 30 per cent. In a catarrhal appendicitis or in an interstitial appendicitis the leukocytosis is trivial; but in cases of abscess or of gangrene of the appendix the leukocytes, as a rule, rise from 15,000 to 20,000. It is to be remembered, however, that when the patient is profoundly septic, the systemic condition is so depressed that leukocytosis is impossible; hence leukocytosis may be absent in trivial catarrhal cases or in grave cases with overwhelming general sepsis. This latter condition, however, is extremely rare. The blood-count will not help one in making the differentiation between appendicitis and an inflammatory disorder of the pelvis or abdomen, but will aid one in making a diagnosis from typhoid fever, intra-abdominal or pelvic neuralgia, and movable kidney (see J. C. DaCosta, Jr., study of 118 cases: "Am. Jour. Med. Sciences," Nov., 1901).

Appendicitis in Children.—The disease is more common than was once thought (page 850). There is usually a history of antecedent attacks of gastro-intestinal disorder. The onset is apt to be sudden, but may be insidious, and the symptoms as a general thing are violent, and the progress of the disease is rapid. Vomiting is usually more violent and prolonged than in adults. Abscess seems especially prone to form, but general peritonitis is by no means uncommon. Occasionally in young children pneumonia begins with so much pain and rigidity in the lower abdomen that they seem to point to appendicitis, and an attack of appendicitis may begin coincidentally with or soon after a pulmonary inflammation. I have seen three cases in children in which pneumonia was ushered in by abdominal pain and rigidity. In children the inflammation usually reaches the right side of the pelvis, hence a digital rectal examination must always be made. This usual involvement of the pelvis is responsible for the frequent and painful micturition which is very common (Karewski). An attack of peritonitis in a child is more

apt to result in general peritonitis than is the same disease in an adult (Selter).

Appendicitis in Pregnant Women.—Appendicitis is not common during pregnancy. When it does occur, it is more dangerous than in the non-pregnant. In about 40 per cent. of cases abortion occurs, and usually the child dies from infection. In some cases of successful operation pregnancy continues to term. The diagnosis is often very difficult because of the enlarged uterus.

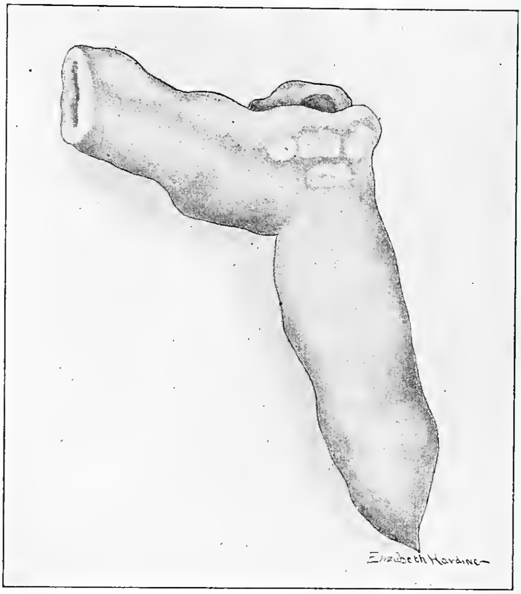


Fig. 453.—Tuberculous appendix with perforation and abscess.

Tuberculous Appendicitis (Fig. 453).—Acute symptoms may develop resembling acute appendicitis. There is usually a history pointing to stenosis, the stenosis existing at the ileocecal valve.* There is always great thickening, and an abscess of large size is apt to form. The cecum usually, but not always, is involved in the tuberculous process. Chronic cases, with palpable enlargement, are sometimes mistaken for cancer of the cecum.

Malignant Disease of the Appendix.—This is a very rare condition, impossible of recognition clinically, but sometimes discovered postmortem or during operation for supposed acute or chronic appendicitis or pelvic disease. The condition may be carcinoma, sarcoma, or endothelioma, and usually there are distinct inflammatory changes. According to Rolleston and Jones ("Am. Jour. Med. Sciences," June, 1906), in 33 reported instances appendices the seat of primary malignant disease have been removed during life. Eccles reports another case ("Am. Jour. Med. Sciences," June, 1906), making 34 in all. In most cases the appendix alone is diseased; in some the colon or glands of the mesentery are involved. In less than 10 per cent. of cases concretions were found. The chance for permanent cure after removal of an appendix the seat of malignant disease is very good if the disease is limited to the appendix, and is particularly good if the growth is spheroidal-celled carcinoma (Rolleston and Jones).

Treatment.—If the diagnosis were always certain from the beginning, and if the case were seen at the very start by a surgeon, immediate operation in every case would be eminently proper. If this plan could be followed, the mortality from appendicitis would be extremely small. At this early stage the peritoneum is free from infection, and the appendix can be rapidly and easily removed without risk of infecting the peritoneum. Whenever I see

* Andrews, Annals of Surgery, Dec., 1901.

a case early, that is, during the first twenty-four hours of the attack, I practically always advise operation. Unfortunately this plan cannot be habitually followed. As a rule, when the physician first sees the case, the appendicular peritoneum is inflamed, and the surgeon usually sees the case at even a later period than the physician. At this time the barriers of leukocytes are being heaped up to limit the spread of infection, and delicate encompassing adhesions are usually being formed. Even in these later cases I often, in fact usually, advise operation. Operation at this stage may be imperatively necessary, because of the rapid spread and dangerous nature of the process; but when operation is not done, in some cases at least, a temporary limitation will be secured and the case will go on to an interval. Operation in this period is always dangerous; operation in an interval is safe. In some instances, when the case is not seen early, it is wiser to avoid operating at the time, and it is proper to wait for an interval. The period in which the surgeon usually sees the case for the first time is said by McBurney to be "too late for an early operation and too early for a late operation." Those who say "operate as soon as the diagnosis is made," operate, as a rule, in this dangerous period, and in this period I do not believe that every case should be promptly cut. Many cases, it is true, must be operated on as soon as seen, irrespective of the duration of the disease. We must operate promptly if the pulse is small and well above 100; if there is persistent vomiting; if there is delirium; if intestinal obstruction exists; if a chill has occurred; if the pain and rigidity are very marked; if a mass can be felt in the right iliac fossa or by rectal examination; if there is marked abdominal distention; if there are evidences of pus-formation; if the patient is growing worse; if there is or has been shock; or if the pain suddenly passes away without the use of opiates.

In an ordinary mild case, not seen early, in which none of the above-named conditions or symptoms exist, it is best to defer operation. Those who advocate operating upon every case consider such delay reprehensible and dangerous, point out that even in apparently mild cases gangrene or perforation may quickly occur, and cite striking cases to emphasize their belief. There is much force in this view, and it must not be hastily rejected. The choice, however, is not between a dangerous delay and a safe operation, but is rather between a dangerous delay and a dangerous operation. It is a question of two dangers, and each side chooses the danger which seems to it the least. Richardson's elaborate study of 750 cases, showing a mortality of 18 per cent. in operations for acute appendicitis, determines us in the practice of the more conservative plan.

In an ordinary mild case of appendicitis in which operation is refused, it is a common custom to purge by means of Epsom or Rochelle salt. This practice was begun because of the belief that inflammation of the appendix is associated with fecal impaction in the head of the colon. This belief has been exploded, but the treatment is still used, and many regard it as beneficial. If the condition of the stomach prevents the administration of salines, high enemata are usually given. My own belief is that if operation is refused, or if the surgeon determines to wait for an interval, he should follow the plan of treatment suggested by Ochsner to control peristalsis and favor limitation of infection. The patient is kept perfectly quiet, no cathartics are given, no food or drink is administered by the mouth, and thirst is allayed

by enemata of salt solution. Nutritive enemata may be given. It is also my custom to place a hot-water bag instead of an ice-bag over the appendix region.

To permit peristalsis favors diffusion of the infection: to prevent peristalsis is to favor the formation of encompassing and defensive adhesions.

Many surgeons use the ice-bag, but I do not believe in it in these cases. We have already shown (page 93) that cold as a remedy for inflammation is useful only in the brief stage of hyperemia, and when a surgeon sees a case of appendicitis, there is certainly more or less stasis. Cold adds to stasis and does harm, and I am persuaded that the routine use of the ice-bag is responsible for some cases of gangrene. Again cold actually antagonizes the migration of leukocytes and the formation of adhesions.

Heat is a remedy which favors limitation of the process. It relieves stasis, stimulates the activity of the leukocytes, favors the formation of an encompassing barrier of phagocytic cells, and aids the cellular proliferation which leads to the formation of adhesions. Hence I prefer the hot-water bag.

The ice-bag, when applied before the diagnosis has been made, that is, in the earliest hours of the attack, when it might be thought to be most serviceable, allays pain and lessens rigidity in some cases, almost like a full dose of opium, and hence masks the symptoms as does that drug.

Opium should never be given until the diagnosis is made. In the first place, it is not needed, for if the pain is so violent as absolutely to demand opium, operation should be performed. In the second place, opium masks the symptoms, makes the patient feel comfortable, and gives the physician an unfortunate and ill-founded sense of security. The pain about the umbilicus, if severe, can be distinctly and safely relieved by the administration of thirty minims of spirits of chloroform every half-hour until three doses are taken. Opium should not be given if the surgeon, having decided not to operate at once, is awaiting an interval, because it may prevent or delay the recognition of some disastrous change. If a patient refuses operation, it can be given.

When we decide to wait for an interval, the case should be seen again within six hours. We are accustomed to follow McBurney's rule, which is as follows: If on seeing the patient again, six hours after the first visit, the patient is worse, operate at once. If he is no worse, there is no pressing danger.

If in twelve hours after the beginning of the attack the symptoms are not intensified, they will soon begin to abate; if the symptoms have become worse during this time, operate. If in twenty-four hours after the beginning of the attack the severity of the symptoms lessens, it is usually possible to wait for an interval; but if during the second twenty-four hours the abatement in the severity of symptoms has not gone on and there is doubt as to the condition, operate at once.* When the attack has subsided, and about three weeks or more have passed, the appendix can be removed with remarkable safety. After a patient has had two or more attacks of appendicitis all surgeons agree that the appendix should be removed.

If pus is present, some surgeons delay operation in the hope that firm adhesions will form around the pus, and that the necessary operation will simply be the opening of an abscess. I do not believe it is safe to delay operation in a pus case. The pus may become limited, but it may instead

*For McBurney's views, see N. Y. Polyclinic, Jan. 15, 1897.

pass up toward the liver or down into the pelvis. Delay is fraught with peril.

If only one attack has occurred, there may never be another, and the question arises, Should the appendix be removed after one attack? We do not know that a man has really recovered after purely medical treatment. Many cases reported as cured by medical means have subsequently required operation. As Lockwood puts it,* "To say that a man with appendicitis has been cured by medical means is in many cases equivalent to saying that a man with a stone in his bladder has recovered from calculus after the cure of a cystitis by rest in bed."

Even after a first attack, if the appendix remains tender or becomes tender after exercise, or if attacks of colicky pain occur, operate.

In some cases a single attack of appendicitis is followed by persistent dyspepsia and ill health, and in such cases operation should be performed. In the majority of cases, after even one well-marked attack, operation is necessary. It is always necessary after two attacks (see Operation for Appendicitis).

Appendicitis cases which are far advanced in general peritonitis when seen by the surgeon some operators decline to touch. If we make a custom of operating on such cases we will lose very many but will save some few, and these few would have died if we had not operated. To operate spoils statistics, but occasionally saves lives. The operation should consist of a simple incision to relieve tension and afford exit to infected fluids—rapid removal of the appendix if it is easily accessible, otherwise leaving it alone—and drainage of the pelvis. After such an operation the patient is placed in Fowler's position and a continuous stream of salt solution at low pressure is caused to trickle into the rectum (see Murphy's Treatment for Peritonitis, page 869).

Appendicitis in a child is treated exactly as in an adult. Appendicitis in a pregnant woman is treated as in the non-pregnant. Early operation is particularly indicated, and it is not proper to induce premature labor.

When operating upon a woman, bear in mind that ovarian, tubal, or uterine disease may have preceded, actually caused, or resulted from the appendicitis; examine the adnexa and remove them if necessary.

An operation for tuberculous appendicitis is rather apt to be followed by a fecal fistula. An ordinary laparotomy is sometimes followed by cure, but the rule of operating should be, when possible, to remove the appendix and resect the diseased bowel. Andrews † mentions as expedients suited to special cases of tuberculous disease: total exclusion; partial exclusion; lateral anastomosis, and the formation of an artificial anus.

Splanchnoptosis.—This condition is due to relaxation of the abdominal walls, which permits the viscera to move downward. The prolapse may involve all the abdominal viscera, one of them, or several of them. Prolapse of the stomach is known as gastroptosis (page 836); prolapse of the liver as hepatoptosis (page 882); prolapse of the spleen as splenoptosis (page 904); prolapse of the kidney as nephroptosis (page 1101); and prolapse of the intestines as enteroptosis or *Glénard's disease* (page 865).

The causative relaxation of the abdominal walls is most common in

* Brit. Med. Jour., Jan. 27, 1900. † Annals of Surgery, Dec., 1901.

women, but is by no means confined to that sex. It may be produced by ascites, pregnancy, muscular effort, febrile maladies, or wasting diseases. In some cases no cause can be assigned. Such a relaxed abdomen may be thin, but is not unusually thick, the fascial strands and muscular fibers are stretched, attenuated, and separated, the belly bulges downward and forward, and a viscus or the viscera follow because of lack of support.

Enteroptosis, or Glenard's Disease.—This disease is a prolapse of the intestine. It may be but a part of ptosis or prolapse of all the abdominal viscera; it may exist alone; it may be associated with movable kidney, prolapse of the stomach (gastroptosis), of the liver (hepatoptosis), or of the spleen (splenoptosis).

In Glénard's disease the intestines occupy the lower portion of the abdomen, and the belly below the costal margins is flat, is dull on percussion, and the pulsations of the aorta are very evident. The right portion of the transverse colon begins to descend first, and other portions of the intestine follow. The splenic and hepatic flexures are elongated and sometimes there is venous engorgement of dependent parts of the mesentery (Lambotte, in "Presse Med. Belge," 1901, Nov. 24). The victims of this disease are dyspeptic, anemic, and neurasthenic. The condition may arise without apparent cause, may be caused by wearing corsets, by falls, by blows, by lifting heavy weights, and by prolonged vomiting. The dyspepsia is due to dragging on the duodenum, the tube becoming flattened out (A. K. Stone). The flattening of the duodenum may be followed by kinking of the pylorus, and in such a case the stomach dilates, otherwise it does not dilate. Normally the tenth rib is firmly attached by fibrous tissue to the ninth costal cartilage. In enteroptosis the tip of the tenth rib is freely movable and obviously separated from the ninth costal cartilage (*Stiller's sign*).

Treatment.—In many cases medical treatment is of benefit. The following is the usual plan: Employ lavage, massage, and electricity; order a proper abdominal support; insist on regular exercise, and treat the anemia and dyspepsia. If ptosis of the liver, spleen, stomach, or kidney exists, operation may be necessary.

In enteroptosis good results are sometimes obtained by attaching the splenic and hepatic flexures to the abdominal wall (*Lambotte's operation*). Robt. T. Morris removes redundant peritoneum and transversalis fascia; scarifies and shortens the falciform and suspensory ligaments of the liver; rubs with gauze the upper surface of the liver and the under surface of the diaphragm, and approximates the recti muscles. In two cases he also anchored a loose kidney.*

The Peritoneum.

Acute Peritonitis.—Peritonitis, or inflammation of the peritoneum, is a common and important disease.

Aseptic irritation by a traumatism or a chemical irritant produces *aseptic peritonitis*, a condition which is strictly limited; which may produce local pain and tenderness; which may cause aseptic fever from the absorption of fibrin-ferment and the products of tissue-change; which leads to the formation

* Med. News, June 28, 1902.

of temporary or permanent adhesions, and which is, in reality, a process of repair.

Peritonitis, as the term is used by the surgeon, is always due to bacteria. Bacteria may reach the peritoneal cavity by means of an abdominal wound or the entrance of foreign bodies; by extravasations from the stomach, bowel, vermiform appendix, gall-bladder, urinary bladder, kidney, Fallopian tube, or uterus, or by the passage of micro-organisms through the damaged walls of any of these viscera or structures; by way of an open Fallopian tube; from the breaking of an abscess into the peritoneal cavity; from areas of necrosis due to volvulus, strangulation, or intussusception of the intestine; twisting of the pedicle of an ovarian tumor, a floating kidney, or a floating spleen; blocking of a mesenteric vessel by a thrombus or an embolism; gangrene of the pancreas or spleen, and fat-necrosis.* In some cases the peritoneum may contain a point of least resistance, and bacteria contained in the blood reach this point and produce infection. It was once taught that cold could produce peritonitis, but it seems probable that it can only act by producing an area of least resistance. The capacity of the rheumatic poison to produce peritonitis is doubtful.

The peritoneum, as Byron Robinson pointed out and Fowler confirmed, is in reality a great lymph-sac, and peritonitis is lymphangitis. "When the peritoneum is infected the lymphatics furnish an exudate which clots in the lymph-channels, blocks them, and limits or prevents absorption. This blocking of the lymph-channels serves to preserve the life of the subject, on the one hand, while a failure in this respect, either because of the enormous and overwhelmingly rapid increase of septic material and the large size and number of channels necessary to destroy and obstruct, on the other hand, permits the destruction of the organism."† Absorption takes place most actively from the region of the diaphragm, hence peritonitis in this region is peculiarly fatal. Absorption takes place very rapidly from the intestinal region, although not quite so quickly as from the diaphragmatic area. Absorption takes place slowly from the pelvic region, hence peritonitis of this region is much less dangerous than is the disease in the intestinal region, and vastly less dangerous than is the disease in the diaphragmatic region (Fowler).

When severe bacterial infection of the peritoneum occurs, exudation of blood-liquor takes place, leukocytes migrate from the blood-vessels beneath the endothelial layer, particularly into the peritoneal cavity, and the causative bacteria rapidly spread about the cavity. The fibrinous exudate, in many infections, coagulates in masses on the free surface of the peritoneum and thus serves a useful purpose by blocking the lymph-channels and hindering absorption of toxins and bacteria. This fibrinous exudate may break down in a wide-spread suppuration or may be organized into an adhesion. In very virulent streptococcic infections a patient may die and there may be scarcely any coagulated exudation or may be none at all. Exudation and migration take place also into the subserous tissues and into the muscular coat of the bowel, and the segment of bowel which is attacked becomes paralyzed and distended with gas, the gas within causes it to rise up, and,

* See Park's "Surgery by American Authors."
† George R. Fowler, "Diffuse Septic Peritonitis," in Medical Record, April 14, 1900.

as peristalsis is absent, obstruction occurs (James P. Warbasse, in "Am. Jour. Med. Sciences," July, 1905). Absorption of poison in peritonitis takes place in part from the peritoneal cavity and in part from the subserous tissues. Warbasse believes that the inflamed peritoneum is scarcely an absorbing surface, but in cases in which coagulated exudate has not formed or has been destroyed, it seems probable that it is an active absorbing surface, and absorption may occur from some regions but not from others.

Various bacteria may be responsible for peritonitis, especially staphylococci, streptococci, pneumococci, and colon bacilli. The infections which spread most rapidly and widely are due to streptococci. In streptococcus infection the protective exudate does not coagulate, barriers of leukocytes are not heaped up, encompassing adhesions do not form, there is rapid absorption of toxins, and overwhelming systemic poisoning. Colon bacilli cause a very grave form of peritonitis, but less rapid and diffuse than that caused by streptococci—in fact, the process is often encompassed for a time by coagulated lymph, leukocytes, and adhesions. The omentum particularly is thickened, and is apt to apply itself about the area of infection. Staphylococci and pneumococci produce peritonitis which is more apt to be limited than that produced by colon bacilli. In most cases of peritonitis a mixed infection exists; for instance, colon bacilli and staphylococci or colon bacilli and streptococci. In some apparently severe cases of acute peritonitis cultures have remained sterile.

Forms of Peritonitis.—An accurate bacteriological classification is not as yet possible.

Peritonitis can be named, according to regions, *pelvic*, *subdiaphragmatic*, etc.; it can be divided pathologically into *diffuse septic*, *putrid*, *hemorrhagic*, *suppurative*, *serous*, and *fibrinoplastic* (Senn); it can be classified, etiologically, into *traumatic*, *puerperal*, *perforative*, *metastatic*, *scarlatinal*, etc.; and it can be divided, clinically, into *circumscribed suppurative*, *diffuse suppurative*, and *diffuse septic*.

Circumscribed Suppurative Peritonitis.—In this condition, which is frequently met with in appendicitis, the area of infection is circumscribed by coagulated exudate, leukocytes, and adhesions, and an abscess forms. After a time distinct localization becomes evident.

The *symptoms* of circumscribed peritonitis are pain, at first general and then local, tenderness in a particular region, muscular rigidity, distention, vomiting, rapid and often wiry pulse, constipation, fever, great weakness, and dorsal decubitus with the thighs flexed. After a time a distinct mass can usually be detected by palpation, and there may be dulness on percussion, local rigidity, irregular temperature, sweats, and possibly edema of the belly-wall. An abscess, though limited for a time, is always liable to break through its walls and produce general peritonitis. Such an accident may be produced by muscular effort on the part of the patient or by injudicious palpation on the part of the surgeon; its occurrence is announced by shock, and the symptoms of general peritonitis quickly arise.

Diffuse or general septic peritonitis is apt to destroy life even before the peritoneum presents any marked change. Death ensues from the absorption of toxic alkaloids. Septic peritonitis may arise during puerperality, through lymphatic infection; it may be due to infection from without by an operation

or an accident; to perforation of an ulcer; to gangrene of a portion of the intestine; to rupture of an abscess into the peritoneal cavity; or to migration of micro-organisms through a damaged wall of the bowel. Peritonitis due to perforation is called *perforative peritonitis*. Perforation is made manifest by a chill, shock, or rapid collapse. Gas may pass into the peritoneal cavity, and if it does so, the area of liver-dulness may be lessened or abolished. Symptoms and signs of hemorrhage may arise. Diffuse septic peritonitis is announced by a very rapid pulse, which is at first wiry and later gaseous; a temperature which may be at times febrile, but which is apt to be subnormal or which soon becomes so; diffused abdominal pain, general tenderness, dry tongue, delirium, persistent vomiting, constipation, and collapse. Rigidity may exist, and also intestinal obstruction; often, but not invariably, there is distention. In puerperal peritonitis or septic peritonitis from operation there is often no severe pain; in perforative peritonitis there is acute pain. Patients usually die within five or six days.

Diffuse or general suppurative peritonitis differs clinically from diffuse septic peritonitis in the fact that it is less apt to be fatal and wide-spread. In fact, adhesions may form about an area representing a considerable portion of the peritoneal cavity. The causes of both are identical. In septic peritonitis death occurs from absorption of toxins before obvious pathological changes occur in the peritoneum; in suppurative peritonitis the microbes are fewer, are less virulent, or vital resistance is more decided, and suppuration follows marked changes in the peritoneum. In suppurative peritonitis the pyogenic bacteria are always present, and there exists in the peritoneum a wound or damaged area to constitute a point of least resistance.

Symptoms.—Chilliness or a rigor is common, followed by fever, the temperature rising to 102° or 104° F.; pain is intense, and is accentuated by motion and pressure; the attitude of the patient is assumed to relieve pain (he lies upon his back, with the shoulders raised and the thighs drawn up); there are vomiting, obstinate constipation, and rigidity of the abdominal walls, followed by distention when the intestine becomes paretic from septic poisoning. The pulse is rapid; is at first wiry, but may become gaseous. The constipation may be due either to tympanitic distention or to the shock and toxemia inhibiting intestinal peristalsis. Vomiting is frequent. In perforation gas often passes into the peritoneal cavity, and it may obscure the liver-dulness; in tympanites without perforation the liver is apt to be pushed up and its dulness often remains, but on a higher level. Pus unconfined by adhesions will gravitate to the most dependent part of the peritoneal cavity. In some cases of suppurative peritonitis there is no tympanitic distention or rigidity; in some cases there is no fever, and a subnormal temperature may even exist.

Treatment of Peritonitis.—After an abdominal operation the patient may have pain, slight rigidity, constipation, nausea, etc., and the surgeon is in doubt if peritonitis is beginning. Our custom is in such cases to give a saline cathartic, which will empty the peritoneal cavity of fluid, will favor the elimination of microbes, and will combat inflammation. The old-time remedy was opium, but Tait denounced it as inefficient, and showed that it masked the symptoms and often created a false sense of security in the very midst of imminent dangers. The usual method of administering salines is to give ʒj of

Rochelle salt and ℥j of Epsom salt every hour until a free movement occurs. Administer an enema of turpentine at the time the first dose of the saline is given. This treatment will often abolish pain and distention and will perhaps prevent peritonitis after an abdominal operation. If, however, genuine peritonitis actually exists, operation is required. When diffuse septic or suppurative peritonitis exists, the abdomen should be opened. If a perforation exists, is should be closed. If there is an inflamed appendix, it should be removed. Until recently it was surgical custom to break up adhesions, eviscerate, wash the belly with gallons of very warm salt solution, wipe out the space between the liver and diaphragm, wipe out the pelvis, wipe off the intestines, and remove masses of adherent coagulated exudate. We thus produced dreadful shock, tried to cleanse the peritoneal cavity when it is impossible thoroughly to cleanse it, carefully removed the exudate which was doing good by plugging the lymph-spaces, and yet did not reach the infection inside of the lymphatics, which is, after all, the greatest source of danger. Then we drained through two or more incisions and put the patient recumbent in bed, and thus permitted infected material to flow up to the diaphragm, where it is quickly absorbed. The mortality from this procedure was dreadful. John B. Murphy has taught us wisdom and has combined some of the conservative views of Ochsner with the use of the semi-erect position of Fowler, and with the continuous rectal irrigations that several advocated. Murphy's plan is founded upon the following principles:

First, that the initial lesion of the peritonitis should be got rid of as quickly as possible and with the slightest possible amount of handling. For instance, we should remove a gangrenous appendix; we should close a perforation in the bowel, etc. Flushing of the peritoneal cavity with gallons of salt solution is inadvisable. It cannot thoroughly cleanse the peritoneum; it may diffuse the infection to regions that it had not previously reached, and it may tear up adhesions. Inflammatory exudate should not be removed from the intraperitoneal structures. It is nature's method of sealing the lymph-spaces; and if we remove it, we open thousands of channels, previously sealed, to the dissemination of the infection. A drainage-tube should be introduced through the operation wound, and a suprapubic incision should also be made, and a drainage-tube be carried through this into the pelvis. When the operation is completed, the patient should be placed in the semi-erect position, which is commonly called *Fowler's position*. This is done in order that the intraperitoneal fluids may gravitate away from the diaphragm, where absorption is extremely rapid, and into the pelvis, where absorption is much slower.

When the patient is placed in the bed, quantities of warm salt solution are passed slowly into the rectum (Plate 9). The nozzle that is used has one opening on the end and several on the side, and this nozzle is passed above the sphincter. The hose that comes from the nozzle is attached to a reservoir, which is hung but a few inches above the level of the rectum; and the fluid, therefore, enters the rectum only about as fast as the rectum will absorb it. The fluid is allowed to enter continuously, unless it should run out from the side of the tube; if this happens the flow may be cut off for a short time and then allowed to begin again. Gas from the bowel passes into the openings of the tube, and every now and then bubbles up through the reservoir. By this continuous,

low-pressure instillation (*proctolysis*) an enormous quantity of fluid is absorbed by the rectum. In one of my cases seven quarts were taken up in twenty-four hours. The absorption of this fluid greatly increases the amount of urine eliminated and stimulates the heart.

After the water has been entering the rectum for some time, a profuse discharge of sour-smelling material comes from the drainage-tube. This discharge may be profuse for one day, two days, or longer, when its sour smell disappears and it greatly lessens in quantity. The outflow of this fluid from the wound means that saline fluid from the rectum has entered the lymph-spaces and flowed into the peritoneal cavity. Murphy thinks the lymph-current has been reversed. Whether this is true or not the peritoneum certainly seems to become a secreting instead of an absorbing surface, and the lymphatics are washed out. During the time that this treatment is pursued the patient has no food or water given him by the mouth. Stomach feeding is rigidly forbidden in order to prevent peristaltic movements. Small amounts of opium may be given to prevent peristalsis. If the patient is in a weak condition, stimulants or food can be given by the rectum, the solution in the reservoir being allowed to reach a low level, and then the material that it is desired to give being poured in. Besides the above method of treatment antistreptococcic serum is given.

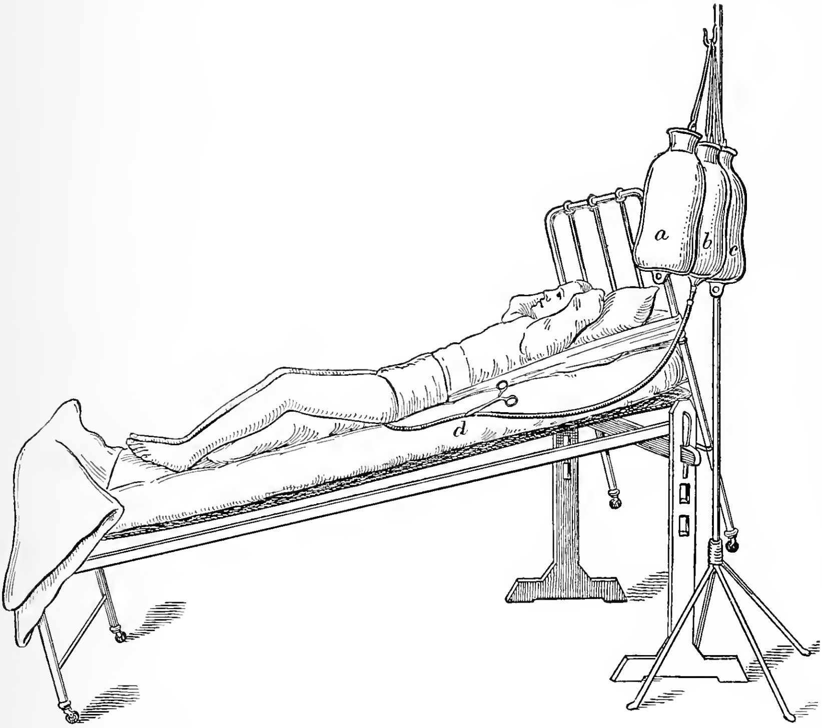
Murphy reported 33 cases so treated with but 1 death (Practical Medicine Series. General Surgery, vol. ii. 1906). Dr. Le Conte has reported 2 cases of recovery ("Annals of Surgery," Feb., 1906); Francis G. Stewart has had 1 case; Dr. John Gibbon has had 2 cases; and I have had 4 successes in the Jefferson College Hospital. I am convinced that this method of treatment is of great value, and that the principles upon which it rests are entirely sound.

A *circumscribed suppuration* is treated as follows: Open the abscess. It will be possible, if the abscess is adherent to the abdominal wall, to open the abscess directly without opening the peritoneal cavity. If this is not possible, after opening the abdominal cavity pack gauze pads in such a manner about the abscess as to prevent the diffusion of pus when the abscess is evacuated. After opening the abscess the primary lesion is sought for and, if possible, removed. The surgeon should not, in most cases, tear away the abscess walls in an attempt to find the primary lesion, but should rather let it go undiscovered. Pack iodoform gauze against the intestines to reinforce the barrier of lymph and insert a tube. It is frequently advisable to leave the wound open and drain with iodoform gauze.

Every patient with peritonitis requires stimulants and frequent feeding with liquid food.

Tuberculous Peritonitis.—Tuberculosis of the peritoneum is not very common. In 1170 autopsies in the Boston City Hospital tubercle existed in some region in 197, and in 14 of these the peritoneum was involved.* Primary local peritoneal tuberculosis is occasionally, though very rarely, seen by the surgeon. In a great majority of cases of peritoneal tuberculosis other distant structures are involved. In about half of the cases the lungs are involved. In 28 cases reported by Bottomly † not one was primary. In every one of these cases the diagnosis was confirmed by the microscope, by the tuberculin test, or by autopsy. In most supposed cases of primary peritoneal

* Bottomly, in Amer. Med., Feb. 15, 1902. † Amer. Med., Feb. 15, 1902.



Murphy's treatment for peritonitis after incision of the abdomen for drainage (Fowler's position and continuous proctolysis of salt solution at a low pressure). *b*, bag containing warm salt solution; *a* and *c*, bags containing hot water to keep fluid in *b* warm; *d*, clip to regulate flow.

tuberculosis another focus of disease exists, but is not demonstrable by clinical methods or has been overlooked. The disease sometimes exists as a part of a general tuberculosis. Tuberculous peritonitis may be only a part of acute miliary tuberculosis. Bacteria may be swallowed with tuberculous food or a tuberculous patient may swallow tuberculous sputum and intestinal tuberculosis may result, the peritoneum being involved later. Peritoneal infection may follow a tuberculous lesion of the intestine, the bacteria may enter by way of the Fallopian tube, the initial lesion may be tuberculous appendicitis or tuberculosis of the mesenteric glands. The germ may lodge from the blood or lymph. The lymphatic form most commonly attacks the cecum. Tuberculous peritonitis is four times as common among women as among men, and most frequently attacks those between twenty and forty years of age, but I have seen it in a child of five and in a colored man of sixty. There are two groups of cases—the common chronic form and the rarer acute condition. The acute form begins suddenly, and such cases, as pointed out by Lejars, resemble acute appendicitis. In either the acute or chronic condition it is frequently the case that pulmonary phthisis exists. Cirrhosis of the liver is sometimes found with tuberculous peritonitis. There are three forms of chronic tuberculous peritonitis: the *ascitic*, the *fibrinoplastic*, and the *caseous*,* although, as a matter of fact, these so-called forms are only stages of the same disease. Tuberculous infection may exist for some time without causing symptoms, acute symptoms may suddenly arise, or intestinal obstruction may take place. Symptoms sometimes develop quickly after pregnancy. In other cases the symptoms appear gradually and progressively grow more positive.

Symptoms of the Chronic Form.—Usually the disease begins insidiously. The digestion is found to be disturbed, there is nausea, the bowels are out of order, the abdomen is distended and tender, there is occasional colicky pain, and the patient is weak, loses flesh rapidly, and becomes very anemic. Frequently pain is the symptom which leads the patient to seek advice. The pain may be present from the very beginning, it may arise after malaise and gastro-intestinal disorder have existed for some time, but sooner or later it will develop.

In many cases there is ascites, but the amount of fluid is rarely very great. In some cases the fluid is serous, in some seropurulent, in some purulent, and in some bloody. Chylous fluid occasionally exists because of fatty degeneration of tuberculous masses. Ascites may be either unconfined or sacculated by adhesions. In some cases, and especially in early youth, there is little or no ascites, and the condition is characterized by the production of a quantity of adhesions which bind coils of intestine to each other, to the omentum, to the stomach, liver, and other viscera. In this condition, which develops very slowly, small cavities are formed between adhesions and the spaces contain fluid and bacteria. This is the most chronic form of the disease. In any case of tuberculous peritonitis the mesenteric glands may enlarge. There is usually moderate fever, but there may be episodes of high fever and protracted periods of subnormal temperature, or the temperature may be slightly elevated in the evening and subnormal in the morning. When the temperature becomes markedly elevated, pain, tenderness, and distention notably increase. In some cases there is a continued fever resembling typhoid. Tumor-like forma-

* Parker Syms, in Medical Record, April 2, 1898.

tions may be detected. These formations may consist of indurated omentum, encysted exudate, or enlarged mesenteric glands. If diarrhea exists for a long period, there is probably tuberculous ulceration of the gut.

In every suspected case a bimanual examination should be made under ether, in order to discover if there are any matted masses of intestine (Thomson).

In many cases a careful examination will detect tuberculous disease of other regions of the body, particularly of the lungs. If tuberculous disease of the lungs or pleura is detected, if tuberculous glands exist or have been present, if a nodule not due to gonorrheal inflammation is palpable in the epididymis, or if there are indurations in the prostate, the probability of the presence of tuberculous peritonitis is much enhanced. In many cases there is dilatation of the superficial abdominal veins. In some cases tuberculous peritonitis undergoes spontaneous cure. In the majority of instances death ensues from the tuberculous peritonitis directly or from associated or secondary disease in other organs.

If an intraperitoneal tuberculous area caseates, a large cold abscess may form, and such an abscess may break into the intestine or may be opened externally, and may be responsible for the formation of a fecal fistula.

In a case of tuberculous peritonitis intestinal obstruction may occur, the gut getting caught by bands or adhesions, or becoming a rigid tube because of the formation of tubercles.

Symptoms of the Acute Form.—This is sometimes mistaken for appendicitis. It comes on rather suddenly, but a carefully elicited history will usually show the previous existence of malaise, gastro-intestinal disturbance, loss of flesh, and anemia. The symptoms are not so strictly localized to the right iliac fossa as in appendicitis. There are abdominal distention, a certain amount of rigidity, nausea and vomiting, colicky pain which may be very severe, general abdominal tenderness, fever, and exhaustion. It may be possible to palpate masses like tumors, or to feel nodules in the prostate or epididymis, or to detect tuberculosis in some other part.

Treatment.—In some cases there is a tendency to spontaneous cure, and in them medical treatment is of great service. The patient should be placed under antituberculous conditions (page 225), nutritious food and tonics should be administered, the abdomen should be counterirritated and massaged, and purgatives should be given frequently. Guaiacol applied daily to the abdomen is thought by some to be of service, but I doubt it. A mixture is made of 1 part of guaiacol and 5 parts of olive oil; one dram of this mixture is rubbed into the abdomen, and the part is covered with a piece of flannel held in place by means of a binder. If medical treatment is not soon productive of benefit, the advisability of operating must be considered. It is a curious fact, but one confirmed by ample evidence, that after simple abdominal section, without the introduction of germicides and without drainage, at least 30 per cent. of the cases recover from the disease in from six months to one year. Some surgeons doubt the curative effect of operation. For instance, the late Professor Fenger was strongly of the opinion that many patients recover after operation, but not as a result of operation. In his opinion they recover because they were strong, free from fever, and well nourished, and because the disease tended to spontaneous cure. He further believed that some died from opera-

tion because the traumatism lessens the already lowered tissue resistance. The majority of surgeons, however, believe that operation in many cases tends to cure. Ochsner, in a paper before the American Surgical Association in 1902, proved that simple incision and evacuation of fluid tends to cure. It is uncertain how an operation tends to cure. It has been thought that the ascitic fluid is a culture-medium for bacilli, and when it is withdrawn the bacilli die, but opposed to this view is the fact that aspiration is rarely curative. It has been suggested that the operation brings numerous phagocytes to the peritoneum; that it stimulates vital resistance; that it leads to the exudation of antitoxic serum. The entrance of air seems to play a definite and important part in effecting a cure.

The ascitic cases are most frequently benefited by operation. In encysted fluid operation often cures.

In cases in which there are numerous adhesions operation is not so likely to produce a cure. Great care should be exercised in separating adhesions, because the bowel is apt to be torn and a fecal fistula may result. It may be necessary to separate adhesions or short-circuit a portion of gut to relieve obstruction. Drainage should not be used unless a cold abscess exists. Not only is drainage of no service, but it is dangerous; death is more apt to ensue in a drained case and a fecal fistula will arise in nearly one-fourth of the cases. If operation is performed for cold abscess, tube-drainage must be used for some days. In a woman with tuberculous peritonitis the abdomen should be opened in the mid-line, and if the Fallopian tubes are tuberculous, they should be removed. In a man the incision should be made over the appendix, and if this is tuberculous, it should be removed. In either sex it may be necessary to resect tuberculous intestine or perform anastomosis because of stricture. (In confirmation of these views see W. J. Mayo, in "Jour. Am. Med. Assoc.," April 15, 1905.) The Mayos have performed 26 radical tubal operations on cases of tuberculous peritonitis and 25 recovered. Of these, 7 had previously been operated on from one to four times by simple laparotomy ("Jour. Am. Med. Assoc.," April 15, 1905). In a very advanced case, in a case with notably high temperature, or in a case with marked and advancing tuberculosis in another region, an operation should not be performed except to relieve obstruction or drain an abscess. If a patient does not die within a few months after the operation, he will probably recover, and in most cases operation secures at least temporary improvement (Bottomly). The mortality from operation is 1 or 2 per cent. (Fenger).

Pneumococcus Peritonitis.—This condition is an unusual one. It is most apt to arise during the progress or after the termination of pneumonia, but is sometimes primary—is far commoner in females than in males and in children than in adults. Out of 74 reported cases, 57 were children under five years of age (Dr. Max von Brunn, in "Beiträge zur klinischen Chirurgie," Bd. xxxix, Heft i). The condition may appear in a sufferer from otitis media. The symptoms in children are sudden in onset. The first symptoms are general abdominal pain, usually a continuous pain with colicky exacerbations, tenderness, rigidity, vomiting, elevated temperature, distention, and diarrhea. In a few days the symptoms abate and some of them disappear, although pain, tenderness, and rigidity are apt to localize at some point, particularly about the umbilicus, and perhaps remain for a number of

weeks. In such a chronic case physical signs of a fluid collection are usually demonstrable. In the chronic stage, as Brunn points out, there is seldom severe tenderness and there may be no fever at all, and a septic temperature is very rarely observed. Pus may form, and if it does, it contains pneumococci. Adhesions practically always form. These adhesions glue the intestines together and often encompass pus. Rapid emaciation and progressive weakness are always noted. In adults the symptoms are irregular and less characteristic than in children (Brunn). The prognosis is excellent.

Treatment.—Is incision and drainage.

Subphrenic Abscess.—A subphrenic abscess is a collection of pus beneath the diaphragm. The pus, as a rule, occupies a part of the lesser peritoneal cavity; in rare instances it is extraperitoneal (when it is of renal origin); in some cases it is contained in the area between the diaphragm, cardiac end of the stomach, and liver or spleen. It is an unusual thing for such an abscess to break into the general cavity of the peritoneum, but it may break into the pleural sac (Maydl).

Causes.—Perforation of a gastric ulcer, perforation of the gall-bladder or gall-ducts, ulceration of the duodenum, disease of the liver, spleen, pancreas, intestine, appendix, or kidney, hydatid disease, internal injury, metastasis, external injury, caries of rib, or disease of the pleura may be responsible for a subphrenic abscess (Maydl). Charles A. Elsberg* has collected 73 cases of subphrenic abscess after appendicitis. He points out that the condition may arise from direct extension or by way of the lymph-channels, and may be either intraperitoneal or extraperitoneal, although in the majority of cases it is intraperitoneal. In all but seven of these cases there was suppuration about the appendix. The pus was thick and foul in all the cases. In 15 per cent. of them gas was also present, and in 25 per cent. of these cases the diaphragm was perforated. In one case on which I operated the abscess developed after cholecystitis.

Symptoms.—A patient with subphrenic abscess usually complains of pain in the lower part of the chest on the right side. The area of liver-dulness is distinctly enlarged, and there is tenderness in the lower part of the right chest when pressure is made through one or through several intercostal spaces. Frequently friction-sounds may be heard about the region of the dome of the liver. Sometimes the symptoms are obscure or indefinite, and not accompanied with particular pain. If the abscess happens to contain a considerable amount of gas,—and about one-half of such abscesses do contain gas,—not only will there be no increase in the area of liver-dulness, but the normal area of dulness may be diminished or obliterated. The presence of gas is due to some connection with an organ which contains gas. It is very common for a pleural effusion to be associated with a subphrenic abscess. A pleural effusion will be preceded by or accompanied with symptoms pointing to the lung or pleura; and it is to be remembered that the area of percussion-dulness found in the pleural effusion shifts its position whenever the position of the patient is changed, which is not true of the area of dulness found in subphrenic abscess. When the abscess breaks through the diaphragm, the patient develops collapse, cough, and other thoracic symptoms; and if the abscess breaks into a bronchus, the patient will expectorate pus. In sub-

* Annals of Surgery, Dec., 1901.

phrenic abscess the diaphragm of the diseased side is paralyzed—a condition rarely met with in liver-abscess. There are general symptoms of suppuration and a swelling in the subdiaphragmatic region following some recognized causative condition. The history of chills with recurrent fever and sweats is rather indicative of abscess of the liver; but in abscess of the liver there is usually pain in the shoulder-blade of the right side, and this is rarely encountered in subphrenic abscess. The proof of the diagnosis is not, however, obtained until an exploratory incision has been made and the purulent matter has been examined. In many cases the abscess-cavity will be found to contain gas as well as fluid. Empyema and subphrenic abscess resemble each other. In empyema the upper limit of the fluid is concave; in subphrenic abscess it is convex. In empyema the flow of pus through an aspirating-needle will be most marked during expiration; in abscess, during inspiration. The same is true of the rush of gas. In empyema the needle does not oscillate; in abscess it does.* If an abscess contains gas, percussion elicits a tympanitic note over a part of the cavity and there is an alteration in the area of tympany with an alteration in the position of the patient. An abscess of the liver almost never contains gas and decidedly changes the outlines of the organ.†

Treatment.—Incision and drainage. The incision in some cases may be made in the lumbar region, in some cases through the abdominal wall (epigastric region, iliac region, hypochondrium). In other cases the chest-wall is incised, the ninth or tenth rib is resected, and the abscess is opened below the pleura or the pleura is opened and the diaphragm is incised. If appendicitis is the cause, be sure the appendicitis is well; and if not, open and drain freely (Elsberg). If it is necessary to open the pleural sac, first try to stitch the parietal to the diaphragmatic layer of the pleura, or, if this is impossible, protect the cavity with iodoform gauze to prevent infection.

THE LIVER, GALL-BLADDER, AND BILE-DUCTS.

Rupture and Wounds of the Liver.—Rupture of the liver is due to very great force, and is usually accompanied by injury of other viscera. It may be produced by a blow, by a fall, or by the end of a broken rib. The superior surface or margin most often suffers. It is a very fatal accident. Out of 543 reported cases, over one-half died of hemorrhage within twenty-four hours of the accident.‡ At least 80 per cent. will die if not operated upon. Wilms § collected 19 cases, and only 3 recovered after operation. Eisendrath || has collected 37 cases of suture of the liver for rupture and 22 of them recovered (59.5 per cent.). The first operation was performed by Willette in 1888. An attempt should be made to save the patient by opening the abdomen and arresting hemorrhage, and in a suspected case an exploratory operation should be performed. A wound of the liver causes violent hemorrhage which is usually rapidly fatal. Such a wound is apt to divide bile-ducts and allow bile to escape into the peritoneal cavity. Bile, if sterile, will do little harm, but if it contains bacteria, it will produce diffuse peritonitis. The symptoms of a rupture or wound of the liver are those of severe

* Wharton and Curtis, "Practice of Surgery."

† In a case of abscess of the liver secondary to appendicitis operated upon in the Jefferson Hospital the abscess did contain gas produced by gas-forming bacteria.

‡ Mercade, in Rev. de Chir., Jan. 10, 1902.

§ Deut. med. Woch., Nos. 34 and 35, 1901. || Jour. Am. Med. Assoc., Nov. 1, 1902.

intra-abdominal hemorrhage, with collapse, hepatic tenderness, and respiratory embarrassment. Soon after the injury the abdomen is soft and flat, but it quickly becomes rigid and ultimately distended. The diagnosis becomes more probable when it is known that violence was applied in the hepatic region. Usually there is abdominal pain and often pain in the back. Sugar may appear in the urine. In a few cases after several days jaundice and skin itching have been noted. The area of liver-dulness is usually increased. Patients do not always die from a serious traumatism of the liver. Some recover because operation has been performed. Some few recover without operation. This last fact is proved by reports of autopsies in which scars were found in the liver-parenchyma (Nussbaum). The fatality which usually ensues on a liver injury may be due to hemorrhage or peritonitis. If a surgeon is called to a patient suffering from wound of the liver, he must open the abdomen to arrest hemorrhage. If a penetrating wound is suspected, it may be desirable to enlarge the wound in the abdominal wall layer by layer, in order to determine that the liver is wounded. If the left lobe of the liver is wounded, or if it is uncertain which lobe is wounded, the incision should be median. If the right lobe is wounded, a curved incision is made along the line of the costal cartilages. In some cases these two incisions are joined.* The convex surface of the liver can be reached by Lannelongue's plan. Lannelongue resects the eighth, ninth, tenth, and eleventh costal cartilages and draws the ends of the ribs well out. When the wound in the liver is discovered and well exposed, deep sutures of catgut should be inserted in the liver and the capsule should be stitched with fine silk (Schlatter). If sutures fail to arrest hemorrhage, the liver should be sutured to the belly-wall and the wound in the liver packed with iodoform gauze. It is useless to try packing without first attaching the liver to the abdominal wall, because pressure will simply push the liver away and will not arrest the bleeding. The cautery is a very useful means of arresting bleeding. It should be avoided if possible in a large wound, because, even if it arrests primary hemorrhage, secondary hemorrhage may occur. After arresting hemorrhage wash out the abdomen with hot saline fluid, insert drainage, and close the abdominal wound. In a case of the author's in the Philadelphia Hospital the liver was wounded by the sharp ends of fractured ribs. The abdomen was opened, a wound was found, and bleeding was arrested by suturing the liver to the belly-wall and packing the wound. The patient died, and necropsy showed another wound on the posterior portion of the organ. The possibility of such an occurrence should not be lost sight of.

Tumors and Cysts of the Liver.—The liver may be the seat of primary carcinoma, sarcoma, or endothelioma, of angioma, lymphangioma, adenoma, fibroma, myxoma, or lipoma. Many tumors called adenomata are really adenocarcinomata. Secondary malignant growths are far more common than primary neoplasms—in fact, 96 per cent. of liver tumors are secondary. Primary cancer of the liver is found once in every 2000 autopsies (Eggel). The commonest variety is the nodular, but the diffuse form, known as *cancerous cirrhosis*, may occur. The nodular form is most often encountered in the right lobe, and it has been found in persons below the age of twenty. Metastases occur early. "There is always more or less coëxisting cirrhosis of

* See Schlatter, Beiträge zur klinischen Chirurgie, Bd. xv, Heft ii, 1896.

the liver" (Leonard Freeman, in Trans. of Am. Surg. Assoc., 1904). It takes origin from the hepatic cells. The frequency of cancer of the liver secondary to cancer of the stomach has already been alluded to. The commonest primary tumor of the liver is cavernous hemangioma. It is especially apt to take origin in the atrophying liver of an elderly individual.

Among the cysts occurring in the liver are blood cysts, congenital cysts, bile cysts, and hydatid cysts. Terrier and Auvray in 1901 collected 52 operations for hepatic tumors.

Angiomata have been removed successfully by hepatectomy, a cautery being used to cut through the normal liver tissue around the base of the tumor. Enucleation is not feasible because of excessive hemorrhage. If a tumor is pedunculated, the base may be encircled by an elastic ligature held in place by a steel needle, and five or six days later the tumor may be cut across with the cautery.* I assisted Prof. Keen in such an operation.

Carcinoma of the liver has been extirpated, but it is seldom that a growth is recognized early enough and is found to be sufficiently limited to justify such a procedure. Operation is proper only when there is a limited nodule of primary cancer. In 1901 Terrier and Auvray collected 9 operations for primary cancer. In most cases there has been rapid recurrence or secondary growth, but Schrader's case was well at the end of seven years and Leonard Freeman's at the end of sixteen months. (For operative methods see Leonard Freeman, in Trans. of Am. Surg. Assoc., 1904.)

Hydatid cysts of the liver may be of small size and productive of no signs or symptoms; or may be of large size and productive of the signs of tumor. In the epigastrium the mass may be prominent and may fluctuate. In cyst of the right lobe the dulness is found in the axillary line and the growth encroaches on the pleura. In a large cyst fluctuation and hydatid fremitus may exist. Hydatid fremitus is a vibration imparted to the palpating fingers of one hand when the fingers of the other hand knock upon the cyst. There may be no discomfort produced by even a large cyst, but, as a rule, the patient suffers from a dragging sensation in the epigastrium and pressure-symptoms. Suppuration in the cyst produces the symptoms of abscess of the liver and septicemia. Rupture of the cyst produces shock and even death. Rupture may take place into the pleural sac, the lung, or the peritoneal cavity. If the shock is recovered from, inflammation arises, the area of which depends upon the structures damaged. The escape of even a small quantity of hydatid fluid into the peritoneal cavity produces urticaria (*hydatid toxemia*). Aspiration for diagnostic purposes is not advisable.

Treatment.—Exploratory incision may be necessary to confirm the diagnosis, and the operation is completed at this time. After exposing the cyst it is packed around with gauze and a trocar is introduced. If there is a considerable thickness of liver tissue over the cyst, incise the liver with the cautery knife. When the fluid is evacuated, the sac is incised and is drawn partly through the wound in the abdominal wall, and is attached to the wound-margins (*marsupialization*). The endocyst can then be removed by the hand or by irrigation. A large drainage-tube in introduced.

Abscess of the Liver.—An abscess of the liver may be produced by

* Russell S. Fowler on "Tumors of the Liver," Brooklyn Medical Journal, Dec., 1900.

bacteria, especially staphylococci and streptococci. These organisms reach the liver by the general circulation, or, what is more frequent, are taken up from the intestinal tract and reach the liver by the portal circulation, or pass to the liver by the lymphatics. Appendicitis with lymphatic infection may result in hepatic abscess. A subphrenic abscess may break into the liver and thus induce a liver abscess. Liver abscess may directly result from peritoneal infection. The fact that abscess of the liver is in hot countries frequently preceded by amebic dysentery led to the presumption that amœba coli produces the abscess, and in a large majority of cases of tropical abscess amebæ exist in the pus or at least on the abscess walls. Habitual intemperance and constant overeating predispose to abscess of the liver. The disease may follow traumatism, dysentery, diarrhea, cholangitis, suppuration of a hydatid cyst, gall-stones, typhoid fever, appendicitis, and a chill to the surface of the body.* Abscess of the liver may be metastatic, and such abscesses are multiple. It may be caused by foreign bodies and parasites. A tropical abscess is an abscess of the liver in an inhabitant of a hot country.

There are three forms of abscess of the liver: traumatic, pyemic, and tropical.

Traumatic abscess may result from a wound of the liver or may follow a contusion without a break of the skin. In the latter case bacteria from the blood are arrested in the injured liver tissue. Such an abscess is usually solitary. Streptococci, staphylococci, or colon bacilli may be found.

Pyemic Abscess.—Multiple abscesses exist, but they may fuse into one. It is frequently due to suppurative inflammation of radicles of the portal vein, infected emboli forming and reaching the liver; it may follow ulceration of the intestine, hemorrhoids, or appendicitis.

Occasionally abscess may arise from the extension of an infective process, such as pylephlebitis, or in cholelithiasis with obstruction. In these latter cases both the bacillus typhosis and the pneumobacillus of Friedländer have been found as the direct bacterial agent. Colon bacilli are a common cause. Abscess of the liver following appendicitis may be due to portal infection (*portal pyemia*) or to lymphatic infection. It is usually multiple, but in a case of mine in the Jefferson Hospital it was solitary, several cavities having probably joined to form one. Echinococcus cyst of the liver may suppurate and form abscess. I operated unsuccessfully on one such case which was brought to me by Dr. Hultsizer. The round-worm, the liver fluke, and the balantidium coli sometimes cause abscess, and, finally, it has been observed in measles, epidemic influenza, and perforating ulcer of the stomach.†

Tropical Abscess of the Liver.—Tropical abscess of the liver is rare in temperate climates, but is extremely common in the tropics. Its usual antecedent in either climate is dysentery. The reason for the great frequency of the disease in tropical regions is that the chief causative agent, the amœba coli, is found widely distributed in hot countries; and that passive congestion of the liver is a common condition among the white inhabitants of tropical regions. It has been pointed out that tropical abscess is particularly common among white persons that abuse alcohol, the condition of passive congestion of the liver making that organ a nutritious soil for a fruitful infection. Pre-

* G. B. Johnston, Annals of Surgery, October, 1897.
† Major Chas. F. Kieffer, U. S. A., in Phila. Med. Jour., Feb. 21, 1903.

disposing factors are protracted malaria and chilling of the surface of the body.

Major Charles F. Kieffer, U. S. A.,* in a lecture on tropical abscess of the liver, states that in his own experience he found, in a series of 33 abscess cases in soldiers, that dysentery was present in every case; and that in a second series of 25 cases in natives and civilians he elicited a history of dysentery in 22 cases. Some observers—notably McLeod—state that dysentery is the antecedent factor in 97.5 per cent. of cases. Kieffer points out that in all the figures allowance must be made for a number of latent dysenteries, as well as for cases in which no effort was made to elicit a history of dysentery one or two years previously. It is also to be remembered that a case of amebic infection of the colon may have been so mild in the beginning as to have caused but a transient diarrhea, which the patient may have forgotten. Again, as Kieffer observes, amebæ occasionally exist in the colon without producing any dysenteric evidences. His conclusions are that from 20 to 25 per cent. of severe amebic dysenteries lead to the formation of abscess of the liver, and that at least 85 per cent. of all tropical abscesses are due to infection with the amœba coli. Occasionally, an abscess begins very soon after the dysentery; but, as a rule, it does not form for some time afterward—weeks, months, a year, or even two years.

When an abscess of this sort forms in the liver, that organ becomes enlarged and congested, and an area or areas of necrosis exist in it. But one abscess may be present; there may be an abscess with satellite abscesses about it; several abscesses may coalesce, making a very large cavity; or genuine multiple abscesses may exist. In about 70 per cent. of cases, however, the tropical abscess is solitary (Kieffer).

The right lobe of the liver is the region most frequently involved. The abscess is found in the right lobe in from 70 to 80 per cent. of cases; and it is more often toward the convexity of the liver than toward the base.

An abscess of the liver contains characteristic and peculiar material; it is different from the pus found in other abscesses, and, in fact, is not pus, but is necrotic liver-substance. Liver abscesses due to pyogenic organisms contain true pus; a tropical abscess, free from pyogenic infection, does not. Ordinary pus contains hordes of leukocytes; but the pus of a tropical abscess contains very few. Riesman is of the opinion that the reason there are so few leukocytes is that the abscess contains a substance that, by chemotaxis, repels leukocytes. The pus is of a reddish-brown color, is thick, and frequently contains some blood. Occasionally it is offensive in odor. Microscopic examination shows it to contain portions of necrotic liver tissue, some liver-cells that are not destroyed, elastic tissue, blood, pus-cells, and amebæ (Kieffer). On bacterial examination it may be found that the pus is infected, containing staphylococci, streptococci, or pyogenic bacteria. In about 20 per cent. of the cases the pus contains neither bacteria nor the amœba coli. In over 60 per cent. of the cases the pus of a recently opened abscess is free from bacteria. In cases in which the fluid is sterile it is possible that bacteria were originally present, but have died. The reason for the death of micro-organisms in this pus is in great doubt; because, as Riesman points out, bile cannot kill them, and organisms may be grown in

* Phila. Med. Jour., Feb. 21, 1903.

the pus. Kieffer says that in the large majority of cases amebæ are readily demonstrable in the pus; but that in some few cases it is necessary to rub a piece of gauze on an abscess-wall in order to obtain amebæ, and that in others they can be demonstrated only after the abscess has been discharging for some days. The causative rôle of the amœba has been doubted by some observers, but most surgeons who have had experience in the tropics believe it to be a fact.

Symptoms.—The symptoms may be very definite and positive; they are frequently misleading and obscure; and in some cases nothing whatever directs the surgeon's attention to the liver until the patient passes a huge quantity of pus at stool or coughs up an enormous amount of the characteristic material. If rupture takes place, death usually ensues. As a rule, the symptoms of a tropical abscess are positive and marked.

Kieffer sums up the chief symptoms under four heads: *fever*, *sepsis*, *enlargement of the liver*, and *pain*. In about three-fourths of the patients fever and sweats are definitely present; in about one-fourth they are absent or are very trivial. The type of fever met with is what has been previously spoken of as hectic. Usually there is an evening rise, preceded by a chilly sensation or by a chill; and as the temperature begins to fall, toward morning, there is a profuse sweat. It is seldom that there is any violent chill, though there is frequently a slight one. The sweats are extremely exhausting. They may occur either during the night or in the daytime, according to the time in which the patient sleeps. Kieffer says that they should not be called night-sweats, but rather *sleeping-sweats*. In very chronic cases there may be no pyrexia. As a rule, the temperature resembles that of malaria, but it is not controlled by quinin and the blood is free from malarial parasites. Sometimes the temperature suggests typhoid, with the exception that from time to time there are episodes of subnormal temperature. The patient loses flesh and strength, the appetite fails completely, and the skin becomes pasty or dirty yellow.

The entire liver is usually enlarged, and the enlargement may be detected by percussion, and in some cases a hard, smooth area can be palpated. Sometimes the liver reaches as high as the third rib anteriorly, or to the spine of the scapula behind, and it may extend downward to the anterior-superior spine of the ilium. It is rarely, however, that the enlargement takes place in a downward direction; it is usually upward. In many cases the right side of the chest appears to be rather full, and sometimes there is actual obliteration of several intercostal spaces. If an abscess becomes adherent to the surface, there may be skin edema and dusky discoloration. In very rare instances, if a very large abscess comes near the surface, fluctuation may be obtained. By auscultation it is frequently possible to obtain friction-sounds in the region of the diaphragm and the superior surface of the liver.

The liver becomes tender. This tenderness may be developed particularly by pressure upon the lower edge of the orgon, and sometimes by pressure through the intercostal spaces. There is not always pain, but, as a rule, there is. The pain may be dull and heavy; but as the abscess nears the surface of the organ, the pain becomes sharp and lancinating. The pain is persistent and is not strictly localized, but radiates to the back,

the right shoulder-blade, and the point of the shoulder. Pain is increased by pressure, coughing, sudden or violent movement, and is sometimes felt in the esophagus when food is swallowed. When the upper surface of the liver is involved, the patient breathes as if he had pleurisy; and pleurisy frequently does develop, with marked effusion.

Paralysis of the diaphragm rarely occurs in abscess of the liver; and the respiration is not much affected, unless the diaphragm of that side and the pleura become involved, though the patient frequently has a dry cough. A severe cough suggests that the abscess is on the convex surface of the organ. Such a cough is aggravated by recumbency. Kieffer points out that the patient lies on his right side, and almost on the right front aspect, the shoulder being drawn down and the right knee drawn up, to relieve the tension of the abdominal muscles. In about one-fourth of the cases of tropical abscess of the liver jaundice occurs; usually, however, it occurs only when the abscess is on the inferior surface. Jaundice does not occur unless the common or hepatic ducts are compressed or cholangitis exists. The leukocyte-count is of no particular help in the diagnosis, as there may or may not be leukocytosis. The urine is usually scanty. Diarrhea is a common accompaniment, but constipation may exist, and nausea and vomiting are by no means unusual.

Diagnosis.—With an antecedent history of dysentery the diagnosis is easy. Without such a history, it is always difficult and may be impossible. In the tropics exploratory aspiration is freely used, but exploratory incision, with subsequent exploratory aspiration, if necessary, would seem to be safer and more certain.

Symptoms of Traumatic Abscess.—Are similar to those of tropical abscess.

Symptoms of Pyemic Abscess.—The liver is enlarged and tender, there is slight jaundice, and the general symptoms of pyemia are present.

Treatment of Tropical Abscess.—Make an exploratory incision. If the abscess is adherent to the parietal peritoneum and is not covered by liver-substance, at once proceed to operation. If it is not adherent, or is covered by a considerable layer of liver-substance, stitch the visceral peritoneum to the parietal peritoneum and postpone further interference for forty-eight hours. The operation consists in evacuating the pus with a trocar and cannula, incising the abscess, stitching its edges to the edges of the abdominal wound, irrigating, and inserting a drainage-tube. If the abscess is covered by a layer of liver tissue, after locating it with an aspirating cannula open into it with a cautery knife and arrest hemorrhage by packing. When the parietal and visceral layers of peritoneum are adherent, packing will arrest bleeding; if they are not adherent, packing will only push away the movable liver (John O'Connor). If pyothorax exists, resect a rib, open the pleural sac, and reach the abscess in the liver by an incision through the diaphragmatic pleura and the diaphragm (*transthoracic hepatotomy*).

Rogers and Wilson ("Brit. Med. Jour.," June 16, 1906) advocate aspiration and examination of the pus. If amebæ only are present, they inject a solution of quinin, a material quickly fatal to amebæ. The dose is 30 grains of bihydrochlorate of quinin in a sterile solution. If the abscess holds less than 10 ounces of pus, the quinin is given in 2 ounces of fluid; if it holds more, in 4 ounces of fluid. The authors report 2 cases cured by this method.

Treatment of Traumatic Abscess.—Is the same as for tropical abscess.

Treatment of Pyemic Abscess.—Surgery is usually futile, because multiple abscesses exist, but an operation should be performed in the hope that it may do good. In a case in the Jefferson Hospital in which abscess of the liver followed appendicitis the patient recovered after operation.

Hepatoptosis (Floating or Movable Liver).—Hepatoptosis may be congenital, but is usually acquired. In a congenital case certain ligamentous supports of the liver are absent. In the following discussion the acquired form is the variety referred to. This condition is rare. Ninety-eight cases have been reported.* It is a form of splanchnoptosis and is due to relaxation of the abdominal wall and stretching of the supports of the liver. It may occur alone, but it is more often a part of a general abdominal relaxation or of Glénard's disease, and often a kidney is movable, or uterine displacement or hernia may exist. The liver may descend into the lower abdomen, may be upside down (Demarquay), may rotate on its transverse axis (Griffiths), the anterior surface may become posterior, or the organ may lie with the superior surface in the right flank and the inferior surface looking to the left,† may be movable, or may be anchored by adhesions. It is most common in women. The liver is supported by ligaments and also by the inferior vena cava, which vessel is firmly adherent to the central tendon of the diaphragm (Faure), by the abdominal wall, and by the intestines (Glénard). The cause of the condition is in dispute. It can result from relaxation of the belly-wall, relaxation of the ligaments, enteroptosis, great enlargement of the gall-bladder, increase in weight of the liver, atrophy of the connective tissue between the liver and diaphragm, pregnancy, the growth of a liver tumor, and tight lacing. Either a strain, cough, or the dragging of an adherent tumor may be the exciting cause.

Signs and Symptoms.—An abdominal mass may appear suddenly after a blow or a strain, and if it does appear suddenly there is always pain in the hepatic region, nausea, and weakness. When the condition comes on gradually, there may be no symptoms for a long time, but, as a rule, there is some pain in the loin which becomes worse after exercise or effort. In rare cases jaundice appears, and occasionally there is ascites. The abdominal walls are relaxed and the signs of splanchnoptosis are manifest. When the patient stands, a transverse furrow of skin covers the lower part of the umbilicus (*Glénard's sign*). In most cases the shape, the movability, and the absence of the liver from its proper position are diagnostic. Even when the organ is dislocated and attached in its new situation, it is missed from its proper abode, and palpation outlines the characteristic shape. When the patient lies down, the liver usually returns to place, and in most cases it can be restored by manipulation. In some cases, however, it will not return to place and cannot be restored by manipulation. A floating liver causes a recognizable enlargement in the right loin, and the mass usually moves on respiration.

Treatment.—In many cases the patient can be kept comfortable by wearing an abdominal support, and can be distinctly improved by the use of massage and electricity to the abdominal wall, the administration of tonics, and a course of forced feeding. If these means fail and the patient suffers,

* J. H. Carstens, Jour. Am. Med. Assoc., May 17, 1902.
† Terrier and Auvray, Rev. de Chir., Aug. and Sept., 1897

an operation should be performed. The operation of *hepatopexy* was devised by Marchant. He opens the abdomen and tries to restore the liver to its proper position. This can usually be accomplished. In some cases it can be done after adhesions have been separated. In other cases it can be only partially accomplished. After the liver has been restored, he sutures it by means of catgut or silk to the abdominal wall or costal cartilages, the stitches passing through the hepatic parenchyma and being carried through the liver by means of a round and blunt needle. The sutures attaching the liver to the belly-wall are tied beneath the skin. Marchant scarifies the dome of the liver in order to favor adhesions. Ramsay rubs the upper surface of the liver with gauze to promote adhesion and transfixes the round ligament with a suture which is carried around the cartilage of the seventh rib. In a severe case Depage advises us to associate hepatopexy with an excision of a portion of the abdominal wall to amend relaxation (*laparectomy*). If, in operating on a floating liver, it is found impossible to get the liver back into its normal position, fix it with sutures as near its proper abode as is possible. Terrier and Auvray report 11 cases of hepatopexy. One case died and eight completely recovered.

Floating Hepatic Lobe (Partial Hepatoptosis).—This condition is not uncommon in cases of chronic disease of the gall-bladder and is most often met in cholelithiasis. It is believed that it can be caused by tight lacing. A tongue-like projection forms upon the right lobe of the liver (*linguiform lobe*). It can be palpated below the costal margin and the dulness of the mass on percussion is continuous with liver-dulness. A linguiform lobe can usually be moved laterally and forward and backward; it is always tender and is sometimes the seat of pain.

Treatment.—When this condition is associated with gall-bladder trouble, it may disappear, or at least cease to cause pain, when the gall-bladder is drained by cholecystostomy. Langenbuch has successfully removed a linguiform lobe.

Cholecystitis (Inflammation of the Gall-bladder).—Inflammation of the gall-bladder is produced by infection. Healthy bile is sterile; and when bacteria are found in the bile, the condition is one of disease. Micro-organisms may find entrance into the gall-bladder by way of the blood, the bile becoming infected secondarily to the infection of the gall-bladder; or they may enter by way of the ducts, from the intestine. The conditions that follow infection depend upon the characteristic tendency and the virulence of the infecting germs. A trivial infection produces mucous catarrh; a more active infection causes suppuration, and possibly ulceration; a very violent infection leads to gangrene.

In most cases of cholecystitis an inflammatory swelling blocks the cystic duct, and obstructs it so that the bile stagnates in the gall-bladder. In many cases this condition lasts but a short time; and when the obstruction is relieved, bile flows down the duct. Occasionally, as a secondary consequence, cholangitis, or infection of the hepatic ducts, follows.* Occasionally, also, the obstruction of the duct is not relieved, and a quantity of clear, thin mucus gathers in the gall-bladder and overdistends it—the condition known as *hydrops*. The gall-bladder may likewise become distended with

* Joseph McFarland, Proceedings of the Phila. Co. Med. Soc., Sept., 1902.

pus, constituting an *empyema* of the gall-bladder; and any overdistended gall-bladder may rupture. In cases of very chronic inflammation of the gall-bladder this structure becomes fibrous and contracts, until it may become no larger than the thumb, in which condition it may contain a very small amount of thickened bile. In some inflammatory conditions due to infection the bile mixes with thickened mucus, and micro-organisms form the nucleus upon which bile salts are deposited. Thus are gall-stones formed (McFarland). As the same author points out, cholelithiasis may result from cholecystitis, and may cause chronic cholecystitis, because the stones existing in a gall-bladder are sources of irritation.

Bacteriology of Cholecystitis.—It has been proved by abundant observation that the fact that bile contains micro-organisms is no evidence that the gall-bladder is inflamed; but that when the gall-bladder is inflamed, micro-organisms are demonstrable in the bile. We know that the bile is infected during the course of typhoid fever, and that it is frequently so in pneumonia. The colon bacillus is not unusually demonstrable in cholecystitis; and pus-cocci, either in pure culture or mixed with other germs, constitute the most common cause of the inflammation. It is probable that bacteria entering the gall-bladder and not being particularly virulent produce no immediate harm when the flow of bile is unobstructed, though even then they may become the nuclei of gall-stones; but if the bacteria are very virulent, they may actually lead to obstruction. Stagnation of the bile favors infection, and infection may be the cause of stagnation. Each influence reacts upon the other and aggravates the other, and it seems more than possible that infection of the gall-bladder is to be regarded as serious only when there is obstruction to the outflow of bile. The same variety of germ may, under some circumstances, cause catarrhal, and under others suppurative, inflammation; that is, when bacteria are virulent and tissue resistance is slight, suppurative cholecystitis results; but when the bacteria are not virulent and the tissue resistance is powerful, the gall-bladder is not infected at all, or only catarrhal inflammation is produced. I operated upon a case of acute suppurative inflammation of the gall-bladder three weeks after the termination of an attack of typhoid fever. The culture taken from the gall-bladder showed an unidentified bacillus, which was not the colon bacillus or the paracolon bacillus, and which was not identical with the typhoid bacillus or the paratyphoid bacillus. It strongly resembled the typhoid bacillus, but possessed no agglutinative power (the author, in "New York Med. Jour.," April 8, 1905).

A patient in the medical ward of the Jefferson Hospital was supposed to be developing a typhoid relapse, but no fresh spots appeared, and there were pain, tenderness, and rigidity in the region of the gall-bladder. I operated and found the gall-bladder full, dark-colored, and surrounded by numerous recent adhesions. It could be emptied slowly by pressure. There was no pus. It was drained and the symptoms promptly passed away and the man recovered. The culture was reported sterile. I cannot understand this finding, as inflammation undoubtedly existed. It may have been peritonitis rather than cholecystitis, but from what cause is unknown. No culture was taken from the peritoneal cavity. The finding of sterile bile at the end of an attack of undoubted typhoid is of interest.

Catarrhal Inflammation of the Gall=bladder and Bile=ducts.—This condition is known as catarrhal jaundice, acute or chronic, and is usually treated by the physician; but, as A. W. Mayo Robson points out, chronic catarrhal jaundice sometimes resembles the jaundice of organic disease, and is occasionally associated with gall-stones, malignant disease, or hydatid cyst. Therefore, in a case of chronic catarrhal jaundice in which medical treatment fails, surgical treatment must be considered.

Catarrhal Cholecystitis.—This is a catarrhal inflammation of the gall-bladder usually without jaundice. The gall-bladder becomes thick and its mucous membrane is frequently plicated. Very thick mucus is secreted, which gathers in masses, and the descent of these plugs causes pain that is sometimes indistinguishable from that produced by the passage of a gall-stone. Such a plug may temporarily block the cystic duct. In catarrhal cholecystitis the gall-bladder is frequently distended, but rarely admits of palpation; and there are no adhesions to surrounding structures, unless gall-stones have been present (Robson). Catarrhal cholecystitis may lead to the formation of gall-stones; may result from the presence of gall-stones; or may be found in cases in which gall-stones have been present, but have passed. In one case upon which I operated the gall-bladder was enlarged, thick, and without adhesions; the mucous membrane was convoluted; and the viscus was filled with thick, tenacious mucus, and the mucous membrane of the gall-bladder contained many minute concretions. In this case stone-formation was probably beginning to follow upon catarrhal cholecystitis. In another case a woman had presented violent symptoms of gall-stone colic, and stones had been recovered from the feces; but on opening the gall-bladder no stones were found—only a condition of catarrhal cholecystitis. Jaundice is rare in catarrhal cholecystitis unless gall-stones are present; it is, however, occasionally noted. Even if jaundice does occur, it is slight and lasts but a short time. The painful attacks that occur during catarrhal cholecystitis are similar to gall-stone attacks; but the pain is less violent and of briefer duration, and jaundice is not apt to follow the passage of a plug of mucus and is apt to follow the passage of a gall-stone. Further, as Robson has shown, in cholecystitis with gall-stones there is usually tenderness on pressure over the gall-bladder; and there is rarely tenderness in uncomplicated catarrhal cholecystitis.

Treatment.—The majority of the cases recover under medical treatment. If a case fails to recover under medical treatment, one cannot be sure whether there are gall-stones or not; but an operation is indicated in either case. Cholecystostomy should be performed, and the gall-bladder should be drained for a week or two. This treatment will almost always produce cure.

Croupous Inflammation of the Gall=bladder and the Bile=ducts.—This is an extremely rare condition, due to the formation of a thick membrane in the bile-passages, which causes obstruction to the flow of bile and spasmodic contraction of the gall-bladder. The symptoms are identical with those of gall-stones. Robson points out that a study of the evacuations may discover membranous intestinal casts; and that, as membranous enteritis is usually associated with croupous inflammation of the gall-bladder and bile-ducts, a diagnosis may thus be reached. The same author says that one may, in some cases, even find a cast of the gall-bladder in the evacuations.

Treatment.—If medical treatment fails, cholecystostomy should be performed and drainage should be employed for a considerable time.

Suppurative Inflammation of the Gall-bladder and Bile-ducts.—Adopting the classification of Mr. Robson, we divide these suppurative inflammations into simple suppurative cholecystitis, suppurative and infective cholangitis, phlegmonous cholecystitis and gangrene of the gall-bladder, ulceration of the gall-bladder and bile-ducts, pericystic abscess with adhesions, and certain consequences of these conditions, such as stricture of the gall-bladder and bile-ducts, perforation of the gall-bladder and bile-ducts, and fistula of the gall-bladder and bile-ducts. Suppurative inflammations of the gall-bladder and the bile-passages are due to infection with virulent organisms or to infection when the tissue resistance is at a low ebb.

One fact must strike the physician in regard to these cases; that is, that there is a strong similarity between the possible changes of acute cholecystitis and the possible changes of acute appendicitis. In the gall-bladder, as in the appendix, there may be a catarrhal inflammation, which may not advance beyond this stage, or which may advance into a more dangerous form; in each structure, blocking and stagnation favor infection and aggravate existing infection; in each there may be suppuration, ulceration, gangrene, and perforation; in each there may be grave complications and disastrous and fatal consequences; and in each prompt surgical operation is usually life-saving.*

Simple Suppurative Cholecystitis.—This condition is also spoken of as *suppurative catarrh* of the gall-bladder or *simple empyema* of the gall-bladder. It is a rare condition, unless gall-stones exist, or unless some infectious disease—especially typhoid fever—has antedated the condition. I operated for this condition upon a boy of eleven years of age three weeks after the termination of an attack of typhoid fever. It is not only typhoid fever that may be causative, but also other continued fevers. No matter, however, what organism is primarily responsible,—be it colon bacillus, typhoid bacillus, or what not,—a mixed infection with pyogenic cocci usually takes place. Pyogenic cocci may alone be causative. In simple suppurative catarrh of the gall-bladder when the duct becomes blocked, the condition known as simple empyema exists; and when hydrops of the gall-bladder undergoes suppuration, simple empyema is produced.

In an ordinary case of suppurative catarrh following gall-stones one usually obtains the history of a number of attacks of biliary colic, the pain finally having become persistent, instead of intermittent; and a definite swelling being palpable in the gall-bladder region. This swelling is tender on pressure. There are usually constitutional symptoms, sometimes trivial, often severe. The trivial symptoms are a somewhat rapid pulse, sweating at night, and some elevation of temperature. The more severe symptoms are chills, a remittent fever, and profuse sweats. The development of severe symptoms indicates that a dangerous change is taking place—usually ulceration of the gall-bladder, occasionally phlegmonous cholecystitis. Distinct jaundice is rare in simple empyema, though the patient usually shows loss of flesh, has a very poor appetite, and suffers considerably from thirst.

* The author, Proceedings of the Phila. Co. Med. Soc., Sept., 1902.

To distinguish an enlarged gall-bladder from any other intra-abdominal mass is sometimes difficult. An enlarged gall-bladder moves on respiration, unless the mass becomes adherent to the abdominal walls, when it will cease to do so. An enlarged gall-bladder is sometimes mistaken for a movable kidney, and the diagnosis between these conditions is discussed in the section on Movable Kidney (page 1104).

Treatment.—The gall-bladder should be opened and drained by the operation of cholecystostomy. After it has been exposed, it is packed about with gauze pads, a considerable amount of the contents is removed through an aspirator, the gall-bladder is opened and irrigated with salt solution, and a search is made for any cause of obstruction in the cystic duct. This cause should be removed, and any gall-stones that are present should, of course, be taken away. The walls of the gall-bladder will frequently be found diseased and softened, so that it is impossible to apply stitches. In some cases, if the gall-bladder is badly diseased, it should be removed; but in others, incision with drainage is sufficient.

Recurrent Simple Empyema of the Gall-bladder.—In this condition a person develops, at intervals, pain, fever, tenderness, and enlargement of the gall-bladder. Then the symptoms clear up and he is well for a time, but they again become manifest; and at last they may become persistent or violent, because of the development of some complication. In these cases it is impossible, after a number of attacks, to palpate any enlargement of the gall-bladder; and when an operation is performed, the gall-bladder is found shrunken, thickened, and deeply placed, containing some purulent matter, and strongly fixed to the surrounding structures by adhesions.

Treatment.—Cholecystectomy is usually the proper operation.

Acute Phlegmonous Cholecystitis.—Some call this condition *acute empyema*. It is extremely dangerous, and is apt to cause gangrene of the gall-bladder. It is due to infection with extremely virulent organisms. It may produce rapid peritonitis and death without perforation, but oftener perforation takes place. It is generally associated with the presence of calculi, but sometimes none are found; and the condition sometimes develops during typhoid fever or septicemia.

This disease begins with sudden and violent pain in the gall-bladder region. This pain usually radiates toward the right shoulder-blade, and soon becomes general throughout the abdomen. There are tenderness in and great rigidity over the gall-bladder region, thoracic respiration, exhausting vomiting, septic fever, and in some cases jaundice. If an operation is not promptly performed, general peritonitis quickly takes the patient's life. In one case upon which I operated there were intense jaundice, tenderness, violent pain, abdominal rigidity and distention, chills, and septic fever; and when the abdomen was opened, it was found that a portion of the gall-bladder was gangrenous and that a calculus projected through the gangrenous opening.

It is this form of cholecystitis that is especially likely to be mistaken for appendicitis. In making a diagnosis the situation of the primary pain is of importance, and likewise the situation of the tenderness; but a displaced gall-bladder or an abnormally situated appendix will lead to error. Acute phlegmonous cholecystitis is usually accompanied by absolute constipation, and the sudden onset and the abdominal distention may lead to

the disease being mistaken for intestinal obstruction. It may also be confused with perforating ulcer of the stomach or of the duodenum.

Treatment.—In any case of doubt an exploratory incision should be made. If phlegmonous cholecystitis is found to exist, the gall-bladder should, whenever possible, be extirpated; but if the desperate condition of the patient forbids this operation, it should be surrounded with iodoform gauze and a drainage-tube should be carried well up toward the cystic duct.

Pericystic Abscess.—Pericystic abscess is a condition that may follow infection of the gall-bladder. It is especially common in the condition known as recurrent simple empyema. When a pericystic abscess exists, there are great localized abdominal tenderness and rigidity and the temperature is usually indicative of suppuration. The causative micro-organisms may have passed through a diseased gall-bladder wall, rupture not existing; or the abscess may follow ulceration or perforation of the gall-bladder wall.

Treatment.—Operation should invariably be performed, though it is frequently difficult. After a pericystic abscess has been drained, it will be found necessary in some cases to extirpate the gall-bladder; whereas in others, cholecystostomy and drainage will prove sufficient.

Suppurative and Infective Cholangitis.—The usual cause of infective cholangitis is gall-stones lodged in the common duct, particularly those cases in which a gall-stone acts as a ball-valve. A. W. Mayo Robson, though he believes that infective cholangitis does occur when the gall-stones are freely movable in the common duct, sets it forth as his experience that it is much more common in such cases to find gall-stones impacted in the common duct.

In such cases the patient gives a history of attacks of gall-stone colic without jaundice for several years, and then of attacks followed by temporary jaundice (page 893). Finally comes an attack that is followed by a chill and fever; and jaundice, varying in intensity, ensues upon this, and now though it may fade, it seldom completely disappears between the attacks of pain. Robson points out that the interval between the attacks may be short or long, and that the rigors may be repeated daily or at uncertain intervals; that the gall-bladder is usually, but not always, contracted; and that after the condition has persisted for some time, the liver becomes distinctly enlarged. There are tenderness over the gall-bladder or in the epigastric region, loss of flesh, and persistent jaundice which may vary in hue.

Infective cholangitis, even after it has lasted for a considerable length of time, may be recovered from; but it may pass on into an acute condition in which poisoning takes place from the biliary elements, suppurative cholangitis may arise, an empyema of the gall-bladder may develop, and there may be an abscess of the liver or some other dangerous or fatal complication. The ague-like attacks of infective cholangitis have been called by Charcot *intermittent hepatic fever* (page 893).

Treatment.—After an incision has been made, the duct is opened and the cause removed; but, as Mr. Robson points out, the complication should be anticipated. When one finds that carefully applied medical treatment has failed to free the patient from gall-stones, they should be removed surgically.

Suppurative Cholangitis.—Suppurative cholangitis is usually a development of the ordinary infective cholangitis, which has just been discussed.

Among the other causes that Robson sums up are acute infectious diseases, particularly typhoid fever and influenza; cancer of the bile-ducts; and hydatid disease.

In this condition the liver enlarges notably and becomes tender. In some cases there is an empyema of the gall-bladder, but this is rare; in fact, the gall-bladder is usually very much shrunken. When, in a chronic case, there are enlargement of the liver, blocking of the common duct, and enlargement of the gall-bladder, the inference is in favor of cancerous obstruction of the common duct. If the obstruction is due to cancer, there will usually be little pain; but when it is due to gall-stones, there will be violent attacks of pain, accompanied by rigors and fever, with deepening of the jaundice. In this disease there is always jaundice, usually unfading; but in cases of ball-valve gall-stone in the duct it will be mitigated from time to time (page 893). The patient suffers with septic fever and very rapid loss of flesh.

The condition is generally fatal, unless operation is performed early. There is a strong tendency for abscess of the liver to form, and in one case upon which I operated a subphrenic abscess had developed.

Treatment.—Cholecystostomy with free and prolonged drainage. If an abscess of the liver exists, it should also be drained. If gall-stones are gathered in the common duct, they should, of course, be removed.

Typhoid Cholecystitis.—As previously stated, typhoid bacilli are usually present in the bile during, and perhaps are present months or years after, an attack of typhoid fever. They are not always present, however, for in a case of cholecystitis following typhoid on which I operated an unidentified bacillus was found ("New York Med. Jour.," April 8, 1905); in a case on which I had made an artificial anus for typhoid perforation and subsequently performed intestinal resection I drained a greatly distended gall-bladder at the second operation and cultures of the bile remained sterile; and in a case of typhoid with distended and apparently inflamed gall-bladder on which I operated the bile was reported to be sterile. Because typhoid bacilli are usually present in the bile during typhoid does not mean that most cases of typhoid have cholecystitis; cholecystitis is not very common, and arises when bacilli are very numerous or very virulent, when vital resistance is lowered, when there is antecedent inflammation of the gall-bladder, when there are gall-stones, and particularly if there is a block of the duct causing stagnation of bile. Bacilli then may do no harm at all, but they may cause a catarrh, a purulent catarrh, suppuration of the gall-bladder walls, suppuration outside of the gall-bladder, or perforation. When bile or inflammatory exudate contains typhoid bacilli, agglutinins are present and may precipitate masses which become nuclei for gall-stones.

The most usual period for cholecystitis to arise is during the third week of the fever, but it is not uncommonly met with during convalescence and is perhaps mistaken for a relapse.

The condition may arise months or a year after the attack of typhoid, and yet a pure culture of typhoid bacilli may be obtained from the gall-bladder. Strange to say, cases of cholecystitis have been operated on in persons giving no history of having had typhoid, and typhoid bacilli have been obtained from the gall-bladder. Such a person may have had a very mild attack of typhoid, or he may be immune to typhoid fever and yet the bacillus may be

capable of causing inflammation. Many cases of typhoid cholecystitis are probably unrecognized because of the trivial symptoms, or because a high position of the liver renders the real seat of pain obscure, because the general symptoms are uncertain, because toxemia blurs perception of pain, or because the condition is confused with appendicitis. It is rare in children, more common in adults. Most infections result from the bacilli ascending the common duct, some are by way of the lymphatics (Charles H. Mayo), some by an adhesion of the gall-bladder to the bowel, some by way of the portal circulation and the bile-ducts. Mixed infection may occur, and a secondary staphylococcus infection may be followed by disappearance of the typhoid bacilli. The symptoms of typhoid cholecystitis are pain and tenderness in the gall-bladder region, rigidity of the upper half of the right rectus muscle, perhaps a palpable mass, an elevated and remittent temperature, sweats, perhaps jaundice, and sometimes leukocytosis. In some cases perforation occurs. Erdmann reported 1 case and collected 34 from literature ("Annals of Surg.," June, 1903).

In an ordinary case without perforation incise and drain the gall-bladder.

If perforation exists, do cholecystectomy if possible; if not, drain. No attempt should be made to suture the perforation. If perforation exists and operation is not done, death is practically certain. Of 27 cases not operated upon, all died; of 7 cases operated upon, 4 recovered (Erdmann).

Gall-stones.—Gall-stones are formed during life in the gall-bladder or bile-ducts by the agglutination of materials which have precipitated from bile. The nucleus of a gall-stone may be a mass of bacteria, a blood-clot, epithelium, crystals of cholesterin or carbonate of lime, or a cast of a small duct.* A condition of the body thought to lead to the formation of gall-stones is designated by the term *cholelithiasis* (Brockbank). But one stone may be present or great numbers may exist. Solitary stones may be nearly round or cylindrical. When several stones or many stones exist, the mutual pressure often leads to the formation of facets (Naunyn). In color, calculi may be pale yellow, green, black, or brown. Some are heavier than bile and some are lighter. Brockbank gives the following varieties of gall-stones: pure cholesterin stones, stratified cholesterin stones, common or gall-bladder calculi, mixed bilirubin-calcium calculi, pure bilirubin-calcium calculi, and certain rare forms.† Gall-stones usually take origin in the gall-bladder, but may arise in the common duct, the cystic duct, the hepatic duct, or the smaller ducts of the liver. As a rule, however, calculi in the common or cystic duct were not formed there, but were transported from the gall-bladder or hepatic ducts.

Causes.—Gall-stones are very commonly found postmortem. In Germany it is estimated that they are found in 12 per cent. of all cases. In 1655 autopsies in the Johns Hopkins Hospital gall-stones were present in 6.94 per cent. of all cases.‡ The usual estimate is 5 per cent. of autopsies. The cause is a catarrhal condition of the bile-ducts, due particularly to the entrance of bacteria from the intestine (colon bacilli, typhoid bacilli, pus-organisms, pneumococci). This catarrhal condition causes stagnation of bile. Experimental infection of the gall-bladder producing mild cholecys-

* Bevan, in Chicago Med. Recorder, April, 1898.
† Brockbank's treatise on "Gall-stones."
‡ C. D. Mosher, in Johns Hopkins Hosp. Bull., Aug., 1901.

titis is almost always followed by gall-stone formation.* Welch pointed out that recent gall-stones have bacteria in their center. Cushing tells us that 30 per cent. of gall-stone cases operated upon in the Johns Hopkins Hospital had previously suffered from typhoid fever, but Mayo's experience is not in accord with this view. In view of the fact that bile containing typhoid bacilli must contain agglutinins we can understand how masses could be precipitated to form nuclei. Thirty per cent. of Ochsner's cases had had appendicitis.

The chief predisposing causes are advancing years, insufficient exercise, the consumption of an excess of nitrogenous food, gouty tendencies, conditions which interfere with the emptying of the gall-bladder, cardiac disease, and cancer of the liver. Gall-stones rarely form before the age of thirty-five. The disease is more common in the insane than in the mentally sound, in the white race than in the black, and in women than in men. In 25 per cent. of all females beyond sixty years of age gall-stones are present (Naunyn). The special liability of woman may be brought about by tight lacing, pregnancy, inactivity, or movable right kidney. There are two forms of the condition to be considered: the acute type, due to efforts made by the gall-bladder or duct to expel the concretion; and the chronic condition, in which a calculus is lodged for a long time, or in which, as soon as one calculus is passed into the intestine, "another begins its journey" (Brockbank). The fact that bacteria cause the condition must not lead us to infer that pus is formed. The bacteria are present in small numbers or else their virulence is greatly mitigated; they produce only catarrhal inflammation, quantities of cholesterin are secreted, the bile stagnates, and a stone forms. It is probable that when gall-stones exist they are all due to a common cause and all began to form at the same time. It is not likely that one begins and then another, and so on. After a stone once begins it may progressively increase in size. In many cases the stone or stones never cause trouble. A gall-stone may begin to descend because of violent muscular exertion, external pressure, or at the onset of a fresh inflammation which leads to loosening of the stone. A very small stone usually passes freely. A larger stone in passing causes colic. A still larger stone remains in the gall-bladder, or becomes fixed in the cystic duct or the intestinal outlet of the common duct. In most cases gall-stones form in the gall-bladder. In some they form in the common duct if stones have previously existed in the gall-bladder. When the common duct retains a stone and is suffering from some degree of obstruction and from infection, stones may form in the hepatic ducts (Wm. J. and Chas. H. Mayo, in "Am. Jour. Med. Sciences," March, 1905).

Symptoms.—The formation of a stone requires several months, and during the antecedent period of gastro-intestinal catarrh, "the *prodromal state*" of Kraus, certain symptoms may exist, viz.: constipation, flatulence, loss of appetite, migraine, uneasy sensations in the epigastrium or right hypochondrium, sallowness of the skin, slight yellowness of the conjunctivæ, scantiness of urine, which excretion is saturated with uric acid, and may after a time contain a little bile. If this condition is not arrested by treatment, it grows worse. The abdomen becomes decidedly distended; pressure over the stomach or liver may cause distinct uneasiness or even pain; acid indigestion is very toublesome; violent attacks of migraine occur; constipation becomes

* Gilbert, in Archives générales de méd., Aug. and Sept., 1898.

more decided, the feces become clay-colored, gastralgia may occur, the skin is apt to be slightly jaundiced, itching is complained of, the patient is irritable and sleeps poorly. The liver is found to be enlarged, and the urine contains distinct amounts of bile. When the patient reaches this stage, gall-stones are very liable to form. These symptoms may pass away even if a concretion forms. It is quite true that in some cases a stone exists for years without causing trouble; but it may greatly aggravate the condition. In fact, gall-stones give rise to active symptoms when infection occurs or when the ducts become occluded and cease to drain. If infection occurs, it may pass away, but seldom does so. When a stone forms, pain is apt to become a marked feature of the case. John B. Murphy ("Med. News," Nov. 2, 1903) points out that in a person with stones in the gall-bladder there may be:

1. The pain of acute inflammation, the result of a severe infection. In this condition there are abdominal rigidity and contracted gall-bladder.

2. The pain of tension. In this there is not persistent abdominal rigidity, but pressure always causes sudden and transient tension of the belly muscles.

3. Referred pain, which may exist with either of the above conditions. *Colic* is spasmodic pain, and means that a stone has left or is trying to leave the gall-bladder, and is in or is trying to enter a duct. Murphy's method of demonstrating tenderness of the gall-bladder is most valuable, and I always use it. It is as follows: Hook the fingers well up under the liver and tell the patient to take a deep inspiration. On inspiration pain becomes acute and respiration suddenly ceases. A sense of pressure or of soreness in the hepatic region, the result of cholecystitis, has added to it sudden and transient paroxysms of pain, due to the passage of thick bile from the gall-bladder and small ducts, or of gravel from the small ducts, urged on by bile pressure. When a stone begins to pass from the gall-bladder, violent colic is experienced. Such a colic usually comes on very suddenly, and often about three hours after a meal. It may, however, come on gradually, the patient complaining greatly of flatulence. The pains are violent, spasmodic, and paroxysmal, and over the hepatic and epigastric regions, "radiating upward over the right half of the thorax" (Kraus), and passing particularly from the epigastrium to the right shoulder-blade. The patient is profoundly nauseated and usually vomits, the abdomen is distended, and a condition almost of collapse is soon reached. The attack lasts a variable time, and terminates by the stone passing into the intestine or falling back into the bladder. After its conclusion, if the feces are examined carefully during several days, the stone may be discovered. The fact that no stone is discovered does not prove that no stone was passed, because a cholesterin stone will be destroyed in the intestinal canal. If the stone passed, jaundice almost invariably follows the colic in about twenty-four hours and lasts several days. If stones do not pass from the cystic duct so as to enter or protrude into the common duct, jaundice does not occur. In 80 per cent. of my cases (excluding common duct cases) there was no history of jaundice. If the stone is impacted, after a time the pains become less violent, but again and again the patient suffers from aggravation of them. An individual may get about with impacted stone, but again and again fierce attacks of colic occur, and if the stone is wedged immovably in the common duct, producing absolute obstruction, the patient becomes and remains deeply jaundiced. Continued deep jaun-

dice is seldom seen in common duct stones, because they are seldom absolutely fixed and hence seldom produce complete obstruction. Usually the stone moves from time to time or is at least lifted so that bile gets by it at intervals. This condition constitutes the "*ball-valve*" *stone*, and in it jaundice, though always present more or less, is at times much more intense than at other times. It is a jaundice in which the hue is yellow, not deep brown, and it is a jaundice that wanes and deepens. In certain cases attacks of gall-stones are accompanied by febrile seizures resembling malaria and called *hepatic fever*, or *Charcot's fever*. The temperature rises rapidly, becomes high, is intermittent, a chill or chills often occur, there are jaundice and tenderness of the liver. Charcot's fever is brief in duration. It usually means stone in the common duct. If stones are in the bladder, we are more apt to get a persistent slightly elevated temperature. These intermissions distinguish Charcot's fever from the remittent fever of sepsis, and the absence of the plasmodium in the blood and the history of colic distinguish it from malaria. The fever is due to intoxication with ptomaïns from infected bile retained in the ducts by obstruction. The condition is ominous because it is due to infection.

If a stone lodges in the cystic duct, it does not cause jaundice unless an end of the stone projects into the common duct. It grows in size from incrustation, prevents the entrance of bile into the gall-bladder, and the bladder becomes filled with mucus (*hydrops* of the gall-bladder). If a bladder so blocked becomes infected, pus forms, and the condition known as *empyema* of the gall-bladder exists. An empyema of the gall-bladder may rupture into the bowel, the peritoneal cavity, or even through the skin.

The common duct is involved in 1 out of 5 or 6 cases.* Brewer points out that in 67 per cent. of cases the stone is in the duodenal extremity, in 15 per cent. in the hepatic extremity, and in 18 per cent. in the middle. If a stone *blocks* the common duct, jaundice always exists and persists. Blocking may be complete, and the stone may ulcerate into the bowel or the peritoneal cavity. Blocking may be incomplete, the stone acting as a ball-valve and producing *intermittent* colic and jaundice (Christian Fenger). Fenger points out that if a stone remains fixed in the common duct, the liver becomes tender and enlarged; but if a stone floats about in the common duct, the gall-bladder undergoes atrophy. In complete obstruction the stools become clay-colored and bilirubin is found in the urine. Fluctuating jaundice, with attacks of pain and fever, and a shrunken gall-bladder are strongly suggestive of a "ball-valve" stone in the common duct. Persistent deepening, painless jaundice, the color of the skin becoming brown or even mahogany, associated with a distended gall-bladder, is strongly suggestive of malignant disease compressing the common duct. The above statements constitute *Courvoisier's law*. We may add that a persistent jaundice of yellow hue, varying somewhat, and associated with pain or with actual colic, suggests blocking of the duct by an immovable stone.

Gall-stones may lead to suppurative inflammation of the gall-bladder or bile-passages, ulceration, occlusion of the neck of the gall-bladder, dilatation of the stomach from the formation of adhesions which kink the pylorus, abscess, peritonitis, empyema of the gall-bladder, and cancer of the gall-

* Robson, in Lancet, April 12, 1902.

bladder. If the patient develops distinct infection of the gall-bladder or bile-ducts, he will suffer from chills, fever, and sweats.

Gall-stones may lead to cirrhosis of the liver. A stone may ulcerate into the bowel and cause intestinal obstruction. It may be difficult to make a diagnosis between gall-stones with icterus and cirrhosis of the liver with icterus. In the former case the urine contains bilirubin and in the latter case urobilin.

Treatment.—In the prodromal stage and after recovery from an attack insist on the patient taking considerable outdoor exercise. Direct him to take a cold sponge-bath every morning, to move the bowels freely every day, and to employ a simple diet. He should avoid all highly seasoned foods, pastry, rich soups, fatty food, cheese, alcohol, and sweets. Alkalies internally are of value.

During a colic give an enema, apply hot turpentine stupes over the hepatic region, and administer hypodermatic injections of morphin and atropin. If vomiting does not occur, let the patient drink a large amount of warm water to favor it. After the attack administer a purgative.

When the attack has terminated, examine carefully for any evidence of inflammatory trouble in the hepatic region.

In certain cases operation becomes necessary. Mr. A. W. Mayo Robson advises operation in the following cases:* in frequently recurring biliary colic without jaundice, whether the gall-bladder is enlarged or not; in cases of enlargement of the gall-bladder without jaundice, even if there is no pain; in persistent jaundice which was ushered in by pain, painful seizures occurring, whether or not febrile attacks occur; in empyema of the gall-bladder; in peritonitis beginning in the gall-bladder region; in intrahepatic abscess and in abscess about the liver, gall-bladder, or bile-ducts; in some cases where the stones have been passed, but adhesions remain and produce pain; in fistula cases; in some cases of persistent jaundice due to obstruction of the common duct, although there may be a possibility of cancer existing; in phlegmonous cholecystitis and gangrene of the gall-bladder. Besides these conditions, which may be produced by gall-stones, Robson operates for wounds of the gall-bladder, infective and suppurative cholangitis, and for some conditions of chronic catarrh of the bile-ducts and gall-bladder.† The tendency to operate early for gall-stones is growing. It is true that stones *may* cause no trouble, but sooner or later they are apt to, there is no tendency whatever to spontaneous cure, and medicine cannot dissolve them in the bladder. Early operations are easy and comparatively safe; late operations are difficult and dangerous, and by early operation dangerous complications (infection, adhesions, obstructive jaundice) are avoided. As Maurice H. Richardson‡ says: An early operation is less dangerous than the passage of a stone; complications are avoided or lessened; even if the diagnosis is wrong, the real condition may be found and removed. If obstructive jaundice exists, operation is dangerous because of the possibility of fatal oozing of blood.

The common operation is cholecystostomy, which consists in opening the gall-bladder, removing the stones, and making a temporary fistula in the gall-

* Mayo Robson on the "Gall-bladder and Bile-ducts."

† Robson's treatise, from which the above is taken, is a valuable exposition of the surgery of the gall-bladder and bile-ducts.

‡ Boston Med. and Surg. Jour., Sept. 5, 1901.

bladder (page 965). The fistula is permitted to heal, after a time, hence many call it cholecystotomy rather than cholecystostomy. Operation should be done promptly and should not be delayed. To delay permits the gall-bladder to thicken and shrink, and allows the stone to enter the duct. After drainage gall-stones rarely reform. Wm. J. Mayo collected 2000 operations done by 6 surgeons, and in not 1 case did stones reform. The operation of incision, removal of the stone, and suture of the gall-bladder is known as *cholecystotomy* or *cholecystendysis*. If calculi exist in the common duct, it may be possible, after celiotomy, to manipulate them back into the bladder and extract them from that viscus with a scoop, but this maneuver is impossible unless the cystic duct is dilated. In some cases the gall-bladder is incised, a fistula is made, and the duct and bladder are frequently irrigated. In other cases the stone may be crushed by the fingers manipulating the duct and the concretion within it (*choledocholithotrity*). Robson points out that crushing of the stone is apt to leave fragments which may cause trouble, and it should be done only when the stones are soft. It is wrong to endeavor to force a stone from the common duct into the duodenum. The attempt will fail, and in some cases the patient will be placed in a worse condition by the stone lodging in Vater's diverticulum.* The duct may be opened, and after the removal of the stone closed by sutures (*choledochotomy*) or drained for a time (*choledochostomy*), strands of gauze being carried down to the opening and in some cases a tube being carried up a dilated duct toward the liver. If the stone is impacted near the outlet of the duct, it may be necessary to incise the duodenum in order to remove the stone (*duodenocholedochotomy*). A dilated bile-duct may be anastomosed to the bowel (*choledocho-enterostomy*) or to the surface (*choledochostomy*). The obstruction may be side-tracked by anastomosing the gall-bladder to the bowel (*cholecystenterostomy*) (p. 967). Cholecystenterostomy affords drainage, but does not remove the cause of trouble, and infection is apt to be received from the bowel. In some rare cases of common duct obstruction, in which the gall-bladder is distended and the condition of the patient is desperate, anastomose the gall-bladder to the colon (Robson). In some cases of diseased gall-bladder the viscus is removed (*cholecystectomy*). *Cysticotomy* is incision of the cystic duct.

Carcinoma of the Gall-bladder.—In 405 operations on the gall-bladder and biliary passages the Mayo brothers found malignant disease 20 times (5 per cent. of cases). (See Wm. J. Mayo, in "Med. News," Dec. 13, 1902.) Malignant disease may be primary or secondary. In primary carcinoma calculi are always present, and are apparently causative by maintaining chronic irritation. Stones are seldom present in secondary malignant disease.

Carcinoma of the gall-bladder can usually be palpated. It is hard and nodular, and seldom accompanied by much abdominal rigidity. There will be a long history of attacks of gall-stone colic and of recent or comparatively recent grave loss of flesh. Sooner or later jaundice arises, deepens, and persists.

Cholecystectomy has been employed for this condition, but offers but little hope. In 2 cases in which I opened the abdomen without suspecting malignant disease of the gall-bladder the liver was hopelessly involved. In 1 case in which I operated for a supposed impacted stone in the common duct an inoperable cancer of the common duct was found.

*See A. W. Mayo Robson, in Lancet, April 12, 1902.

Diseases and Injuries of the Pancreas.

Wounds and Injuries.—The pancreas is very rarely ruptured alone, although this sometimes occurs as the result of blows or crushes. In the majority of cases in which the pancreas is damaged other organs are involved; for instance, the stomach, the spleen, and the liver. A gunshot-wound of the pancreas is almost certain to injure the left kidney, the stomach, or the vertebral column. It will be remembered that in the case of President McKinley the bullet passed through the stomach, damaged the left kidney, and injured the pancreas.

Symptoms.—When the pancreas is injured alone, hemorrhage is not usually severe; but if adjacent organs are also damaged, it is sure to be profuse. Hence when adjacent organs are damaged there are apt to be immediate symptoms of severe intra-abdominal hemorrhage; but profound collapse is not often present when the pancreas alone is injured. In fact, symptoms may not arise for a considerable length of time after injury of the pancreas. A diagnosis at this stage is impossible without exploratory operation. Severe injury of the pancreas is usually, but not invariably, fatal. After slight damage of the gland the patient may completely recover; but, as a rule, he partly recovers, and, after a number of weeks, a smooth tumor, palpable in the epigastric region, is formed. When operation is performed, this tumor is found to be back of the stomach. It contains a quantity of blood, clot, and pancreatic fluid. Such a fluid collection is in the lesser peritoneal cavity and is called a cyst, though it is not a true cyst of the pancreas. Robson and Moynihan, in their valuable treatise on "Diseases of the Pancreas," explain the formation of this collection of fluid as follows:

The injury lacerates the posterior layer of the lesser sac of the peritoneum and the pancreas, to which it is adherent. Blood and pancreatic fluid enter the lesser peritoneal sac. Peritonitis follows. The foramen of Winslow is blocked by adhesions; and the lesser peritoneal cavity, being now a closed sac, is distended with a serous exudation mixed with blood and pancreatic fluid. Collections of this character form very rapidly, and several pints may gather in a few days. Other results of injury to the pancreas are abscess, pancreatitis, and true cyst-formation.

Treatment.—In a gunshot-wound of the abdomen, when exploration leads the surgeon to surmise that the pancreas has been injured, this organ should be approached by dividing either the gastrocolic omentum or the transverse mesocolon. The pancreas may also be exposed by dividing the gastrohepatic omentum. Accessory injuries must be carefully noted; and if a bullet has penetrated the posterior wall of the stomach, the pancreas is almost certain to be damaged. One should remember that, as Park says, even after opening the abdomen it is difficult to explore the pancreas, especially in a stout person. If there is no evidence of posterior perforation of the stomach by a foreign body, one may assume that the pancreas has escaped. When the pancreas is exposed, if it is found to be bleeding, the vessels should be ligated and the tear in the gland should be sutured, care being taken not to puncture the main duct of the gland. If this duct has been cut, it must be carefully sutured. In some cases of gunshot-wound it is necessary to resect a portion of the gland.

At the termination of the operation posterior drainage at the costo-vertebral angle should always be obtained.

In cases of crush with pancreatic injury the associated injury to other structures usually proves rapidly fatal; but in a less severe case the abdomen may be opened for exploration, and if this is done, the surgeon should proceed as previously directed.

The question of excising a lacerated portion of the pancreas is one of great interest. It is known that dogs have lived after complete excision of the pancreas, but the operation is not justifiable in man.* In man, however, quite large-sized pieces of the gland have been removed and recovery has followed. Hence it is justifiable to excise a hopelessly damaged portion, bearing in mind Park's caution that the chief danger in excising a portion of the pancreas is injury to the splenic artery.

Movable Pancreas.—In cases of splanchnoptosis the pancreas may become considerably displaced, though this condition cannot be recognized without opening the abdomen. So far, I know of no case in which fixation has been attempted; though, of course, theoretically it could be done.

Pancreatitis.—Pancreatitis often leads to the production of jaundice; always to very rapid loss of weight; occasionally to the presence of fat and sugar in the urine; sometimes to the presence of fat in the stools; and frequently to the condition known as fat-necrosis. Robson and Moynihan point out that when there is no diarrhea and the stools contain undigested muscle-fiber, one may assume that there is a deficiency in pancreatic juice. When there is a blockage to the secretion from the pancreas, if salol is given by mouth, salicyluric acid does not appear in the urine. The test is made by putting gr. xv of salol into gelatin capsules hardened with formalin (Sahli) and giving them with a roll and a cup of water. If pancreatic ferment is in the intestine, salicyluric acid appears in the urine in one hour or one hour and a half; if the ferment is absent from the intestine, salicyluric acid is not found in the urine because the salol is not split up and absorbed. The test for the acid is ferric chlorid, which, in the presence of the acid, turns the urine violet. The general cause of pancreatitis is infection. Often obstruction of the common bile-duct is followed by infection and suppuration of the pancreatic ducts and pancreatitis. Besides the general cause, which is infection, various exciting causes may be named, among which are gall-stones in the common duct and calculi in the pancreatic ducts, traumatism, cancer of the stomach or duodenum, catarrh of the stomach or duodenum, and many infectious diseases. It thus becomes evident that the infection may be by way of the blood; but, undoubtedly, in the vast majority of cases, the infection comes by way of the duct. One manner in which the disease may be produced was suggested by Halsted and Opie, of Baltimore: A stone becomes impacted in the outlet of the common duct; the pancreatic duct, where it emerges above the common duct, not being blocked. The bile and pancreatic juice are thus prevented from entering the duodenum, and the bile flows back into the pancreatic ducts.

That strange condition known as *fat-necrosis* is often present in pancreatitis. In fat-necrosis the fat is decomposed into fatty acids and glycerin. The glycerin is absorbed, but the fatty acids unite with calcium salts and

* Park, Annals of Surgery, Dec. 15, 1901.

remain in the tissues, forming patches of yellowish-white color and varying size. These patches are found in the fat beneath the peritoneum, in the omentum, and in the mesentery, and even in distant parts (for instance, the pericardium).* It is an undoubted fact that fat-necrosis is not uncommonly found after diseases and injuries of the pancreas; and many assume that it is produced by the entering of the ferment of the pancreas into the fatty tissue. How the ferment gets there is a matter of some doubt. In the case of a wound of the pancreas one can understand the flow of the secretion and its imbibition by adjacent parts; but in other cases one must assume that it has been absorbed by the lymphatics and distributed to more distant parts. When one reflects that in some conditions of the pancreas there is no fat-necrosis, while in others this condition arises, it is presumable that the pancreatic conditions associated with it are such as to permit the fat-splitting ferment to diffuse into neighboring tissues.

In pancreatic disease *hemorrhage* into that organ is common. The hemorrhage is not, of necessity, fatal, but frequently is so. Occasionally death takes place as the result of sudden pancreatic hemorrhage in a person apparently in excellent health. It is thought by Robson and Moynihan that during the existence of cancer of the pancreas there is a strong tendency to excessive hemorrhage after operation. In one case of my own the patient bled to death after the performance of cholecystostomy for obstructive jaundice. The oozing of blood in this case was from the margins of the gall-bladder and the adjacent peritoneal surfaces. We therefore conclude that in certain conditions of the pancreas there is a tendency to local hemorrhage in that organ; and that there may also be a tendency to the development of a general hemorrhagic diathesis, the general hemorrhagic tendency being much increased if jaundice exists. During acute inflammation of the pancreas hemorrhage is almost certain to occur into that gland; in other varieties of inflammation hemorrhage may occur or may be absent.

Forms of Pancreatitis.—This disease is divided by Robson and Moynihan into the acute, the subacute, and the chronic form; and they say that recorded cases demonstrate the fact that three distinct classes of inflammation may arise: (1) Cases that die within forty-eight hours of the beginning of the trouble. In this group hemorrhage is usually found; and if fat-necrosis is present, it is limited in area. (2) Those that live for some weeks after the beginning of the trouble. In these cases the pancreas may become necrotic or suppuration may occur. Fat-necrosis is usually wide-spread. (3) In the third class of cases long-continued inflammation or repeated attacks produce sclerosis of the pancreas.

Acute Pancreatitis.—The symptoms of this condition come on suddenly and consist of violent pain in the epigastric region, vomiting, constipation, rapidity and weakness of the circulation, cold extremities, and collapse. The pain is extremely violent and is intensified in paroxysms, and there are distinct tenderness and rigidity of the epigastrium. The patient vomits the contents of the stomach and then bilious matter. Distention soon becomes distinct in the upper portion of the abdomen. The patient presents the appearance of one suffering with peritonitis. This condition is not unusually mistaken for intestinal obstruction, but in acute pancreatitis the constipation is not abso-

* Robson and Moynihan, on "Diseases of the Pancreas."

lute; the patient passes gas, and may even have a bowel movement as the result of the administration of an enema. The condition is usually fatal within a few days; but in very rare instances recovery takes place. In acute pancreatitis from stone in the common duct there is no leukocytosis (Murphy).

The diagnosis cannot be made with certainty and is merely an inference. Reginald Fitz tells us that the existence of this disease should be suspected when a person previously in good health, or who has complained only of occasional attacks of digestive disorder, is suddenly seized with severe pain in the epigastric region, followed by vomiting and collapse; and when, within twenty-four hours or more, there appears a circumscribed swelling in the epigastrium which is resistant or tympanitic. When an exploratory incision is made in the abdomen, if fat-necrosis is detected, the diagnosis becomes certain.

Treatment.—The exploratory operation is carried out in front, and the earlier it is made the better. It is quite true that the patient might, if let alone, pass through the acute stage, and that a local abscess might then form, the treatment of which would be obvious. But the danger of waiting is too great to justify delay. When exploratory incision suggests the condition, the infected area should be exposed either above the stomach through the gastrohepatic ligament (Lund and von Mikulicz), or below the stomach. The pancreas should be incised, hemorrhage should be arrested by ligation or packing, an incision should be made at the costo-vertebral angle, and posterior drainage should be made from the lesser peritoneal cavity. One should follow the rule laid down by Roswell Park, and explore in every case in which the disease is suspected to exist.

Subacute Pancreatitis.—Subacute pancreatitis comes on suddenly, with violent pain, vomiting, and constipation; but there is far less exhaustion and weakness than in the acute form. The vomiting is less marked and the swelling in the epigastric region is not so rapid. The symptoms are similar to those of the acute form, but not so violent nor so rapidly progressive. The temperature frequently rises higher than in the acute form, and it may become irregular, or chills may occur. In many cases the patient seems to grow better after a time, the violent pain abating, though some pain and tenderness remain; but he does not gather strength and continues to lose flesh, and there is usually albumin and is occasionally sugar in the urine. In rare instances fat is found in the urine. In subacute pancreatitis abscess is prone to form. This abscess may make a distinct swelling in front, and may lead to the development of a subphrenic or of a perirenal abscess. In rare cases an abscess of the pancreas tracks its way for a long distance in the subperitoneal tissue; occasionally it opens into the stomach or bowel. Cases of subacute pancreatitis occasionally recover after a long illness, but usually they die.

Treatment.—Exploratory incision. Expose the pancreas, either above or below the stomach; determine the condition; remove purulent matter and necrotic areas; arrest hemorrhage with packing; and insert posterior drainage at the costovertebral angle. In some cases close the anterior wound, and in others leave it open.*

* Roswell Park, Annals of Surgery, December 15, 1901.

Wm. J. Mayo * reports a successful operation for subacute pancreatitis. The patient was a man of fifty-two years, who, seven days before Mayo saw him, had developed violent pain in the epigastrium, collapse, distention, and other signs of intestinal obstruction; but some slight movements had taken place from the bowels, as the result of medication. On admission, the abdomen was tympanitic. An ill-defined mass the size of a fist could be palpated to the right of and above the umbilicus. The pulse was 120 and very weak; the temperature, between 101° and 102°; and there were slight jaundice, restlessness, and hiccough. A diagnosis of gangrenous cholecystitis was made. The abdomen was opened, and the omentum was found to be studded with thick, adherent, infiltrated round spots, the size of a pea or larger. There were some similar spots in the mesentery, and the peritoneal cavity contained bloody fluid. On palpation, the pancreas felt like a pudding in a tight sac; and on aspiration, a little blood was obtained. The gall-bladder was opened, a stone was removed, and some pus was evacuated. Drainage was inserted into the gall-bladder; and eighteen days later there was an enormous flow of bloody fluid, containing bile and pancreatic juice, from the drainage-tube. The patient recovered. This plan of treatment—free drainage of the pancreas by the performing of cholecystostomy—is to be taken into consideration.

Chronic Pancreatitis.—This usually results from disease of the bile-passage. It produces enlargement of the organ, and the enlarged area is hard and feels like a malignant growth. This condition is more common than is the acute or the subacute form. Robson and Moynihan have operated upon thirty cases. The disease is frequently associated with gall-stones or with stones in the pancreatic duct, and occasionally with ulcer of the stomach or of the duodenum. In some cases the condition comes on acutely and jaundice develops rapidly, as it does after the passage of a gall-stone. It is noted, however, that the pain is not in the region of the gall-bladder, but is in the middle of the epigastrium, and it passes to the left, rather than to the right. The tenderness, too, is in the middle of the epigastrium, and not in the gall-bladder region. A series of these attacks may occur, the jaundice growing worse after each attack. In some cases, however, the condition comes on gradually and insidiously, the pain slowly developing, but no violent seizures taking place. There are rigidity of the rectus muscles, rapid loss of flesh, usually vomiting, and considerable flatulence. The gall-bladder is enlarged and commonly palpable.

Treatment.—Exploratory incision, opening and draining the gall-bladder; or the performing of cholecystenterostomy.

Pancreatic Calculi.—When the pancreatic secretion is blocked, stones tend to form; and the blocking may be due to inflammation of the duct of Wirsung, or may result from chronic pancreatitis. The stones may be single or multiple.

Symptoms.—There is pain in the epigastric region, which usually comes on in paroxysms that resemble those due to gall-stones, though they are not so violent. Pain is accompanied by vomiting, exhaustion, and sometimes actual collapse, and may be followed by rigors. Portions of stone are sometimes recovered from the feces, and sugar is occasionally found in the urine.

* Jour. Am. Med. Assoc., Jan. 11, 1902.

Fat has also been noted in the stools in some cases. Sometimes jaundice develops, because the calculus presses upon the common duct.

Treatment.—Pancreatic calculi have, in rare instances, been removed by operation; and this is the proper procedure when the diagnosis can be made. The diagnosis is, however, possible only after exploratory incision. As a rule, no operation is performed until a cyst results or an abscess forms; and when the cyst or abscess is opened, fragments of stone may be found in the fluid, and stones may subsequently come away in the resulting fistula.

Pancreatic Cysts.—Many forms of cyst may develop in the pancreas; the following are set forth by Robson and Moynihan: (1) Retention cysts; (2) proliferation cysts, including cystic adenoma and cystic epithelioma; (3) hydatid cysts; (4) congenital cysts; (5) hemorrhagic cysts; and (6) pseudocysts. What we speak of as pseudocysts have already been considered in discussing effusions into the lesser peritoneal cavity. They result from lacerations of the pancreas. Retention cysts are due to blocking of the pancreatic duct. Congenital cystic disease is extremely rare. Hemorrhagic cysts result from hemorrhage into the substance of the pancreas itself.

Symptoms.—Cysts are somewhat more common in men than in women. A cyst of the pancreas proper is more often met with in the head of the organ than in its body or tail. The cyst may be single or multiple. In its growth it either destroys the substance of the pancreas or it grows away from the pancreas and damages it but little. In some cases the cysts grow to a very large size; and Robson and Moynihan refer to a case in which the cyst attained the size of a man's head, and to another in which it was the size of a full-term pregnancy. A pancreatic cyst is smooth, round, elastic, and rather tense (Robson and Moynihan). The contained fluid varies greatly. As a rule, it is brownish-red in color; in one case upon which I operated it was clear yellow; in some cases it is milky, and in others it is nearly black. The fluid is always albuminous. Urea may be present, and in many cases pancreatic ferments are found. In most cases the cyst adheres so closely to the surrounding structures as to render extirpation practically impossible. A pancreatic cyst of considerable size causes epigastric discomfort, pain during digestion, and frequently vomiting. In some cases the pain is trivial; in others, it is very violent. As a general rule, the patient is constipated; but sometimes diarrhea occurs, and the movements may even contain blood. If the tumor presses upon the common bile-duct, jaundice will develop. The patient loses flesh markedly and with considerable rapidity, and he becomes very weak. In rare instances fat is present in the stools, and in other unusual cases sugar is found in the urine. A test should always be made with salol, to see whether pancreatic ferment is present in the intestine (page 897). In the beginning the pancreatic cyst is behind the stomach; but it enlarges and, as a rule, pushes the stomach upward and to the right side, and the transverse colon downward. The cyst approaches the surface of the abdomen below the greater curvature of the stomach (Robson and Moynihan). The same authors tell us that in rare cases the cyst appears at the upper border of the stomach, and that in others it inserts itself between the layers of the transverse mesocolon. In the case upon which I operated it had worked its way through the subperitoneal tissue into the right loin, and had been looked upon by Professor Montgomery and myself as a hydro-

nephrosis. As a rule, the pancreatic cyst is immovable; but in rare instances it is movable. When a hand is placed in the loin and another on the abdomen, ballottement may be appreciated. If the distended stomach or colon overlies the tumor, there will be a tympanitic percussion-note; but when the tumor reaches the abdominal wall, there will be a dull percussion-note. On inquiring into the history of these cases, it will frequently be found that there has been a severe injury to the upper abdomen.

Treatment.—Exploratory incision makes the condition clear. In the majority of cases the cyst is incised, emptied, and stitched to the wall of the abdomen. This operation may be done in two stages—first, exposing the cyst and fixing it to the abdominal wall; and, second, when adhesions have formed, opening it. As a rule, however, it is performed in one stage, the abdominal cavity being carefully protected with gauze. Some authors advocate exposing the cyst, opening and evacuating it through the abdominal wound, and draining through the loin. Complete extirpation is usually impossible because of the adherence of the cyst. If the cyst is movable, extirpation may be carried out; but the safest operation consists of incision and drainage.

Tumors and Other Growths of the Pancreas.—The pancreas may be affected with sarcoma, carcinoma, adenoma, tuberculous disease, or syphilis.

Treatment.—Attempts have been made to remove tumors of the pancreas. After an exploratory incision has determined the condition, the pancreas is exposed at the point at which the tumor projects. This is usually done by an opening in the gastrocolic omentum. If the tumor is in the tail of the pancreas, however, the exposure may be effected in the flank. When the tumor has been exposed, an attempt may be made to enucleate it. At the present time, however, these operations are in the experimental stage, though tumors of the splenic portion of the pancreas have been removed.

Injuries and Diseases of the Spleen.

Wounds and Rupture.—A wound of the spleen causes great hemorrhage, and if no surgical aid is offered, will rapidly produce death.

Rupture of the spleen is unusual if the organ be healthy, but does occasionally occur. It is rarely found unassociated with other injuries. The spleen may be dislocated as well as ruptured. An enlarged spleen is particularly liable to rupture. Rupture of the spleen produces pain and rigidity in the left hypochondriac region and the signs and symptoms of intra-abdominal hemorrhage. There is tenderness over the spleen, pain over the heart, and great shortness of breath. The bleeding is profuse but slow. The splenic blood contains numerous leucocytes and clots rapidly, hence the bleeding is usually arrested for a time, and the patient does not often bleed to death rapidly and reaction generally occurs (Ballance). The blood in some cases clots so rapidly that it gathers in the left loin, and is not commonly diffused throughout the abdomen. It gives rise to an increasing area of dulness on percussion in the left flank, which, Ballance points out, does not shift when the position of the patient is shifted, as it does in bleeding from other intra-abdominal structures. In some cases, however, the blood remains fluid and spreads throughout the belly, and then there is rising dulness in each flank. The case reported by Le Dentu and Mouchet shows that the blood may remain

fluid ("Bull. de l'Academie de Med.," June 16, 1903). In some cases the signs of hemorrhage are late and they may even be deferred until the fourth day (Eisendrath, "Annals of Surgery," Dec., 1902). Exploratory incision will be required positively to recognize the condition. In Elder's table there are 52 uncomplicated cases. Not a case was operated upon (operation was not the rule until 1890) and 84.6 per cent. died. Eisendrath has collected 50 cases operated upon: 56 per cent. recovered and 44 per cent. died.* Février† has collected 56 ruptures of the spleen. In 46 cases operation was performed and the mortality was 50 per cent. E. Berger ("Archiv für klinische Chirurgie," Bd. 28, Heft 3) collected 168 fatal cases of rupture of the spleen: 145 died during the first day and every one died from hemorrhage. After the first day 23 died. In 90 per cent. of the entire series hemorrhage caused death; in 10 per cent. infection was responsible for death. Hemorrhage is the great danger—hemorrhage of the parenchyma rather than from the great vessels. The parenchyma is friable and contains multitudes of capillaries and veins, there is no muscular tissue, divided vessels do not contract, and the capsule is thin. (The elder Senn in "Jour. Am. Med. Assoc.," Nov. 21, 1903.)

Treatment.—The treatment is evident from the previous remarks. It is as follows: Open the abdomen immediately, the patient being surrounded with hot bottles and hot salt solution flowing into a vein. Explore the spleen and other viscera. If the spleen is damaged, we may do splenectomy (total or partial), may use the suture or the cautery or the tampon, and any other visceral injuries are, of course, attended to.

The usual operation has been total splenectomy (page 970). Out of 80 cases of wounds of the spleen in which total splenectomy was performed within nine hours of the injury, 35 died. In partial splenectomy only the injured part is excised and the wound margins are sutured.

The arrest of hemorrhage by suture is known as *splenorrhaphy*. Lamarchia, in 1896, was the first to perform this operation. The tear or wound is sutured with catgut and the suture line is covered with omentum. Berger collected 14 cases of suturing with 2 deaths, but these were injuries of less severity than those requiring splenectomy. In some cases the tampon can be used. Berger collected 10 cases with 1 death. Another method is to crush the splenic structure slowly with broad forcipressure forceps and suture the crushed margins with catgut. Senn follows this plan.

Abscess of the spleen is a rare condition which is usually metastatic in origin. It may follow typhoid, may develop during pyemia, or may result from injury. Chronic suppuration may be due to tuberculosis or actinomycosis. Pain is felt, and enlargement is noted in the splenic region, and the symptoms of pyemia exist. The abscess may become adherent to the belly-wall, may become encapsuled, or may rupture into a viscus or the peritoneal cavity. Fluctuation can seldom be obtained. What is known as a tropical abscess (Fontoynant and Jourdrau, in "Archiv Prov. de Chir.," No. 11, 1902) may develop during a malarial attack as a result of severe exertion. There are severe pain in the left hypochondrium, dyspnea, and dry tongue. There may or may not be fever. The pus may be sterile. The **treatment** of abscess of the spleen

*Daniel N. Eisendrath, Jour. Am. Med. Assoc., Oct. 25, 1902.
† Rev. de Chir., Nov., 1901.

consists in incising at the outer edge of the left rectus muscle, suturing the spleen to the abdominal wall, opening the abscess, and providing for drainage (Tédenat*). If the abscess is adherent to the abdominal wall, incise it directly.

Tumors of the Spleen.—The spleen undergoes hypertrophy in the course of infectious disease, from amyloid disease, from leukemia, and from Hodgkin's disease. Secondary cancer is seen after cancer of the stomach. Genuine primary tumors are extremely rare. Fibroma, enchondroma, lymphangioma, angioma, and sarcoma occasionally develop. Jepson and Albert report a case of primary sarcoma of the spleen and collected 31 others from literature ("Annals of Surgery," July, 1904). Primary carcinoma is usually medullary and is sometimes melanotic. Secondary carcinoma and secondary sarcoma are more common. Secondary cancer, as stated above, is seen after cancer of the stomach. Hydatid cysts, dermoid cysts, and blood cysts occasionally develop.

Treatment.—The condition may become clear only after exploratory laparotomy. For some tumors splenectomy is indicated. A hydatid cyst is treated as is a cyst of the liver (page 877). A blood cyst is sutured to the incision in the abdomen and is drained.

Splenoptosis, or Wandering Spleen.—The spleen may wander into any part of the general peritoneal cavity. This condition is seldom met with except in women. It is most common in women who have borne children. A wandering spleen may undergo atrophy, engorgement, or axial rotation (J. Bland Sutton). The spleen may be healthy or enlarged from malaria or leukemia. As a matter of fact, it is usually diseased. The organ when displaced drags upon the stomach, producing dilated stomach; it may interfere with the bile-duct, causing jaundice; it may cause intestinal obstruction by forming adhesions, or may cause uterine retroflexion or prolapse by passing into the pelvis.

J. Bland Sutton says this condition may endanger life, as it may lead to rupture of the stomach, intestinal obstruction, splenic abscess, or splenic rupture.† A wandering spleen can be identified by the fact that it has a notch upon its edge, and can be pushed about the abdomen. When this condition exists, the spleen may be missed from its normal situation. Always examine the blood in order to determine if leukemia or malaria exists.

Treatment.—Greiffenhagen advocates suturing the organ in place (*splenopexy*). Most surgeons prefer to perform splenectomy. In a case without leukemia the operation is very successful. Splenectomy for wandering spleen is rarely followed by serious blood-changes or other trouble. The reason is that a wandering spleen is usually a diseased organ, having undergone hypertrophy or fibroid change, and other structures have taken on splenic function. Splenectomy should not be undertaken if leukemia exists. In such a case surgeons usually apply a support and employ medical treatment for the existing disease or endeavor to suture the organ in place. If the spleen were enlarged by malaria, I would perform splenectomy (as I did in one case). If the spleen were healthy, I would surround it with gauze exactly as is done with the kidney in a case of movable kidney. If the spleen were enlarged by leukemia, I would not operate.

* Rev. de Gynéc. et de Chir. Abd., July, August, 1901.
† Brit. Med. Jour., Jan. 16, 1897.

Operations upon the Abdomen.

Abdominal Section (*Celiotomy; Laparotomy*).—There are many different methods of opening the abdomen. The plan selected depends upon the nature and the situation of the disease, and upon the inclinations and the custom of the operator. The abdomen may be opened to attack a recognized seat of disease or to determine what the disease is and where it is situated. Abdominal section performed for the latter purpose is spoken of as exploratory section or exploratory incision.

Of recent years, exploratory operations have become extremely common, and many abdominal conditions would be unrecognized without such exploration, or would be recognized at so late a period as to be beyond the reach of surgery by the time the diagnosis had been made. This is notably true of the surgical diseases of the stomach. The surgeon should, however, not be too radical in employing exploratory operations. The fact that he can explore with such comparative impunity does not release him from the obligation to endeavor by every proper method to make a diagnosis before resorting to operation. I fancy that of recent years the belief that it is almost waste of time to make prolonged efforts to diagnosticate many intra-abdominal troubles because the solution is so much easier by section, has become so common as to have led young and unskilled operators to perform section in cases in which the diagnosis might have been made without this procedure.

Before opening the abdominal cavity for exploratory purposes or to gain access to some area of abdominal or pelvic disease the patient is carefully prepared as for any other operation. In an appendicitis case the patient is moved with the utmost care and is prepared for operation most gently, because of the possible danger of rupturing an abscess. In an emergency case no prolonged or complicated method of cleansing can be employed. The abdomen and loins are scrubbed carefully with soap and water, special attention being given to the umbilicus; the pubic region is shaved, the soapsuds are washed away with sterile water, the surface is gently scrubbed with alcohol and then with a hot solution of corrosive sublimate (1 : 1000), and is covered with gauze wet with the sublimate solution. Whenever there is time it is eminently desirable to prepare the patient the day before. The instruments required depend upon the nature of the case. As a rule, there are required scalpels, scissors, a dry dissector, two pairs of dissecting forceps, hemostatic forceps, pedicle forceps, Hagedorn needles, calyx-eyed intestinal needles, a needle-holder, drainage-tubes, gauze pads, gauze for sponging, silk, catgut, silkworm-gut, the Paquelin cautery, an electric light, also an instrument and a saline solution for hypodermoclysis or intravenous infusion. Always count the instruments, sponges, and pads, and write down the number, and count them again after operation. This rule is adopted so that no instrument, sponge, or pad will be left in the abdomen. The abdominal pads and sponges are not used when dry. Dry sponges injure the peritoneum and favor the subsequent development of adhesions (Sanger). The pads and sponges should be wrung out in hot normal salt solution before being used.

Operation.—An anesthetic is given. In some cases the patient is placed recumbent; in others, is put in the *position of Trendelenburg* (Fig. 454). In the Trendelenburg position the pelvis is elevated, the intestines fall toward the epigastrium, are removed from the necessity of being handled and from the danger of being bruised, the pelvis is thoroughly exposed, and work becomes easier and safer. This position should not be used if there is myocardial disease, as the increased pressure in and flow of blood from the inferior cava may cause fatal acute dilatation of the heart (Kraske, of Freiburg, in Proceed. of German Surg. Congress, 1903). The position is of little use in very fat people (Trendelenburg), and in such a subject may cause intestinal obstruction (Kraske). When this position is employed, the table should be lowered as soon as possible, because gastric hemorrhage may occur (von Eiselberg). The normal position should not be suddenly assumed, as this may cause intestinal obstruction, the omentum being mixed with coils of intestine, pulling the colon down (Pasteau, in "Bulletins and Mém. de la Soc. Anat. de Paris," July, 1905). The position should not be used in a pelvic abscess (König), as it may lead to a flow of pus from the pelvis into the far more dangerous regions above.

Volvulus of the ileum and also volvulus of the large intestine have followed the use of the position. If the Trendelenburg position was employed, before closing the belly return the omentum to its proper position and spread it out (Lauenstein). In every abdominal operation the patient is to be carefully protected from cold, the extremities and the chest are covered with blankets, and sterilized sheets are placed well around the field of operation. The skin is sterilized anew immediately before operating. The surgeon steadies the skin of the belly with the fingers of his left hand, and, holding the knife free in the right hand, makes an incision. For purposes of exploration the incision is made about two inches in length, and it is lengthened if it is found necessary. The abdomen may be opened in the median line above or below the umbilicus. This incision is advantageous for operations on the pelvis, for general exploration, and for certain procedures upon the stomach, the intestines, and the left lobe of the liver. The closure of such an incision, however, lacks strength, as compared with the closure of an incision where strong muscles will overlie the scar through the peritoneum and the transversalis fascia. Incision through the semilunar line is practised by a number of operators. A favorite incision is through the rectus muscle. The fibers of this muscle are separated, the structures beneath it are divided, and, after the completion of the operation, the deeper structures are sutured and the parts of the separated muscle are allowed to fall together. The scar resulting from such an incision is well supported and solid, hence the likelihood of hernia developing is diminished. A favorite method with some is to open the sheath of the rectus muscle, retract the entire muscle aside, incise the posterior portion of the sheath and the structures back of it, and, when the operation has been completed, allow the entire muscle to come back into place, and thus strengthen the deep-seated scar. When the abdominal trouble is in a region that

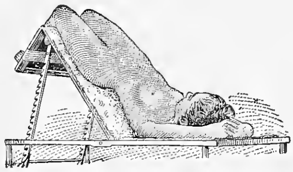


Fig. 454.—The Trendelenburg position.

admits of it, I almost invariably go through the rectus muscle or retract the entire muscle. Besides these methods, there are special incisions, suitable for particular cases: An incision along the costal margin, for reaching the gall-bladder; an incision shaped like the italic letter "*f*," for the same purpose; special incisions for certain operations upon the stomach, for abdominal nephrectomy, etc. Some operators have even used a transverse incision in certain pelvic operations.

In an operation through the median line the first cut goes to the aponeurosis of the external oblique muscle. Clamp the vessels. Do not hunt for the linea alba below the umbilicus, but go right through or between the recti muscles. Above the umbilicus the linea alba is very distinct and the surgeon often cuts through it. Divide the transversalis fascia, beneath which is a little fat, and expose the peritoneum. The latter structure is recognized by its glistening appearance, by the ease with which it can be pinched up between the finger and thumb, and by the readiness with which its opposed surfaces may be made to glide over each other. On identifying the peritoneum, catch it at each side of the incision with forceps, raise a fold, nick it with a knife, and open it with scissors to the length of the external wound. To prevent stripping of the peritoneum a good plan is to anchor it to the belly-wall with a stitch on each side of the incision. Through the wound thus made the abdomen and its contents are explored, the trouble located, and determination made as to whether or not further operation is advisable, and, if it is advisable, what form it shall take. It may be necessary to enlarge the wound. This is done by placing the index and middle fingers of the left hand in the belly, with their pulps against the peritoneum, in the line where the surgeon will cut, to serve as supports to the scissors and as guards to intraperitoneal structures. The scissors are introduced and the wound is enlarged upward, around the umbilicus if necessary. As soon as the incision is complete it is a good plan to push a large pad into Douglas's pouch and leave it there until the operation is finished, when it must be removed. Slender adhesions are stripped off with the finger or are pushed off with gauze; firm adhesions are tied in two places and cut between the ligatures.

The *toilet of the peritoneum* is important after the operation is completed. Following a clean laparotomy, when but little blood has flowed into the cavity, flushing is not required; if much blood has flowed or if septic matter has passed into the peritoneal cavity, after removing the sponge from Douglas's pouch flush the belly thoroughly with hot normal salt solution, empty out most of the fluid, but let a pint or more remain in the abdomen. In flushing the abdomen bear in mind Monks's observations as to the mesentery. It is a sort of shelf. If we follow down the left side of it with the finger the finger must enter the left iliac fossa; if we follow down the right side of it the finger must enter the right iliac fossa. Hence in order to flush the right cavity carry the nozzle down the right side of the mesentery to its root, and in order to flush the left fossa carry it down the left side of the mesentery to the root (Monks, "Annals of Surgery," Oct., 1903). The retention of the saline fluid in the belly minimizes shock. It is absorbed with great rapidity after the operation if the patient is placed with his head lower than his feet, because in this position the saline fluid gravitates to the diaphragmatic region,

where absorption is very active; in fact, in one hour the peritoneal cavity can absorb from 3 to 8 per cent. of the body weight. If there is wide-spread infection with stomach-contents or feces, eviscerate, wipe out the peritoneum with pads soaked in hot normal salt solution, and wipe the intestines carefully, slowly returning them as they are wiped. Extravasated septic matter is apt to collect in the peritoneal fossæ and between the liver and diaphragm, and these regions must be carefully wiped or irrigated. In cases of septic and purulent peritonitis flushing, evisceration, and wiping with gauze are not advisable (page 869). In some cases it is desirable to drain through a lumbar incision. Rutherford Morison has pointed out that a lumbar opening into the right kidney pouch will drain a fossa which holds over a pint of fluid, and which, when the patient is recumbent, is the most dependent portion of the peritoneal cavity. In some cases a drainage-opening is made on each side of the belly or above the pubis or through the vagina. In septic cases it may be advisable to drain with several pieces of iodoform gauze instead of inserting tubes. After most laparotomies drainage is not needed, but it should be used when stomach-contents were extravasated, and it must be used if feces or urine were extravasated, in certain recent septic cases, and when hemorrhage has been severe. We may drain by a rubber tube, strands of gauze, or a glass tube. If a glass tube is used, it is introduced at a lower angle of the wound and reaches the bottom of the pouch of Douglas. This tube is repeatedly emptied during the progress of the case by means of a syringe. Before closing the wound arrest hemorrhage and count the instruments and sponges to know that no instrument or sponge has been left in the belly.

It is highly important that an abdominal incision shall be accurately closed, for any failure of neat approximation will, in all probability, result in the formation of a hernia through the cicatrix. Various methods have been employed. Probably the majority of operators use layer sutures, sewing up the peritoneum with a continuous suture of catgut, and the aponeurotic layers with the same material or with chromicized catgut, and closing the skin with either interrupted sutures of silkworm-gut or a subcuticular stitch of catgut, silkworm-gut, or silver wire. Other operators close the peritoneum with a continuous suture of catgut, then pass silkworm-gut sutures through all the other structures, leaving them for the time untied; put in layer sutures of catgut or of chromicized catgut, and then tie the silkworm-gut sutures. A layer suture makes a beautifully neat approximation, and is frequently quite satisfactory; but I have become persuaded that the dead space, so often left unobliterated when this method of suturing is employed,—a space in which blood and inflammatory exudate may gather,—is a danger to the future integrity of the wound. The combination of a dead space with catgut, a material that is always somewhat uncertain, is an unfortunate one from the surgical point of view. Recently I have returned to the use of the through-and-through suture, applied according to the method of Dr. Joseph Price. This suture is inserted with the straight needle, is composed of silk or of silkworm-gut, is put in close to the margin of the skin, gathers up a great deal more muscle than skin, and then passes close to the margin of the cut peritoneum and transversalis fascia. When these sutures are adjusted, the peritoneal edges are brought into accurate and

firm apposition, the peritoneal surface is overlaid with abundant muscle, the skin-edges are brought into neat approximation, and the formation of a dead space is rendered impossible. When passing the sutures have a gauze pad under the wound and be very careful not to include bowel or omentum. It is necessary to tighten and tie most carefully to prevent omentum being caught in the loop of the stitch. After closing a laparotomy wound, dress with aseptic gauze and wood-wool and apply a flannel binder. In badly infected cases the wound is often kept open.

If a two-inch incision was closed without drainage and primary union takes place, the patient can usually sit up in from ten days to two weeks. A larger incision offers greater danger of subsequent hernia, and the patient should be kept in bed for three weeks. If the wound was kept open for drainage, a prolonged retention in bed may be necessary. In a case in which an incision of considerable length was made, an abdominal support should be worn for a variable time. It limits the movements of cough, laughter, etc., and *reminds* the patient of the necessity of caution in lifting, hurrying, etc.

After-treatment.—The after-treatment depends somewhat on the case, but certain general rules can be laid down. The late J. Greig Smith said many wise things, and among them this: "A golden rule in the treatment of cases of celiotomy is to let the patient alone. Everything approaching to meddlesomeness is to be condemned. The patient must not be upset by fussy applications of tentative therapeutics; when an emergency arises, it is to be met, promptly and decisively, by a method which has been approved trustworthy" ("Abdominal Surgery"). In many cases, immediately after the operation the patient must be treated for shock by methods previously set forth. The treatment of vomiting resulting from the administration of an anesthetic is discussed on page 1034. If vomiting persists during the third or fourth day, it is probably due to the development of inflammation which has caused intestinal paresis; and if it is so produced, medicine is practically useless. In this condition there is usually marked tympanitic distention, and vomiting is, in a sense, a relief. Nothing should be given by the mouth, and the patient should be fed entirely by enemata. The insertion of a rectal tube and its retention for a considerable time may afford relief. Lying on the side is more comfortable than recumbency. Washing out the stomach from time to time gives great comfort and is often of real service.

In the average case of celiotomy, in which persistent vomiting does not occur, the question of feeding is of much importance. Usually, for the first twelve or twenty-four hours, nothing is given by the mouth but small quantities of hot water. The day after the operation, if everything is satisfactory, food is given to the patient. In many cases, however, food is not given by the stomach for forty-eight hours and the patient is fed by the rectum during the wait. He should not be given milk, because it will not be easily digested, may lead to nausea, and causes flatulence. Peptonized milk, if the patient will take it, does not possess these hurtful qualities. At first albumin-water or liquid beef peptonoids should be given and later Valentine's meat-juice, beef-jelly, broth, etc. Food is given every third or fourth hour, and stimulants are administered if required. After the first

twenty-four or forty-eight hours considerable quantities of plain water or Poland water should be taken, when possible, to favor elimination by the kidneys. Hot coffee is not only a stimulant, but is an excellent diuretic. The urine is always scanty after an abdominal operation, and a normal daily amount is not voided for ten days or more. Solid food is not given for seven or eight days. The patient is apt to suffer greatly from thirst, in spite of the hot water given during the first twelve to twenty-four hours. It does not do to give any considerable amount of hot water, and cold water and ice are inadmissible and tend to induce nausea and vomiting. Thirst can be much mitigated by enemata of water. J. Greig Smith recommended an enema composed of from 4 to 20 ounces of tepid water and some brandy. Usually, after the first twenty-four hours, a sufficient amount of liquid can be given to keep the patient free from actual distress.

The bladder must be watched to see that retention does not occur. If retention occurs, a clean catheter must be used at regular intervals. If tympanitic distention occurs after forty-eight hours, a saline purgative should be given and it should be followed by an enema of turpentine (page 868). The rectal tube is frequently of signal service in such cases. If obstruction develops, it is treated as directed on page 843.

In any ordinary case after operation the bowels should be moved after forty-eight hours as a prophylactic measure against distention, peritonitis, and obstruction. From four to eight one-dram doses of Epsom salts are given, in hot water, the solution having been filtered through gauze. The saline is followed by the administration of an enema consisting of soap, water, and half an ounce of castor-oil. Should opium be given? Never as a routine, and not to secure sleep; but if the patient is in pain which not only harasses him but causes him to turn and shift in torturing restlessness, one or possibly two hypodermatic injections each containing $\frac{1}{4}$ gr. of morphin can be given with confidence that the good will overbalance the harm.

Operation for Appendicitis.—Before operating try to locate the situation of the appendix, and the relation the area of infection bears to the ascending colon. The incision should be over the seat of disease. In the rare left-sided cases and in median cases the incision is median. In some cases where the appendix is posterior the cut may be in the loin. In one case I opened a purulent collection through the rectum. In the vast majority of cases the incision is made in the right iliac region.

In acute appendicitis when there is not thought to be a distinct abscess, the incision usually made is two inches internal to the anterior superior iliac spine and perpendicular to a line drawn from the spine to the umbilicus (Fig. 455). The skin incision is usually three inches in length, the upper third of the incision being above the omphalospinous line; the incision in the peritoneum is about two inches in length, but if there are many adhesions, it may be necessary to make it much longer. The oblique incision may be carried out as advised by McBurney, the muscles being separated by blunt dissection. By this method very few nerve-fibers are divided, and hence the operation is not followed by marked muscular wasting, a condition which strongly predisposes to hernia. Further, as Van Hook points out,* the oblique incision enables the surgeon to reach

* Jour. Amer. Med. Assoc., Feb. 20, 1897.

freely all the ordinary areas of appendix trouble, the wound is parallel with the lines of traction of the abdominal muscles and does not tend to gape widely. In an acute case I make an oblique incision, but cut the muscles. In an interval case I separate the muscular fibers. Battle's incision at the outer edge of the rectus muscle is preferred by many surgeons. The anterior layer of the rectus sheath is opened longitudinally, the rectus is drawn inward, and any existing portion of the posterior rectus sheath with the transversalis fascia and peritoneum is incised.

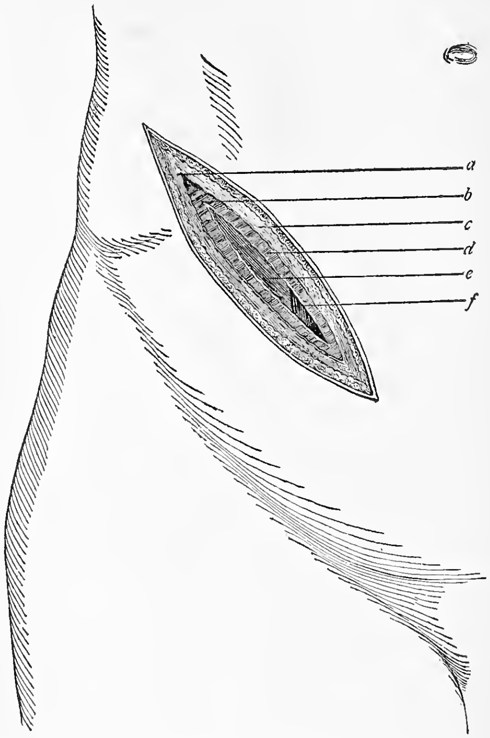


Fig. 455.—Resection of the vermiform appendix, incision through the abdominal wall: *a*, External oblique muscle; *b*, internal oblique muscle; *c*, aponeurosis of external oblique; *d*, aponeurosis of internal oblique; *e*, peritoneum; *f*, outer border of rectus abdominis muscle (under it the deep epigastric vessels) (Kocher).

I have used *Davis's transverse incision* (Figs. 456 and 457) in many interval cases with entire satisfaction (Gwilym G. Davis, in "Annals of Surgery," Jan., 1906). This incision does not divide arteries, and it divides the deep muscles in the direction of the nerves, hence the nerves are not injured. The center of this incision is almost over the base of the appendix. Davis describes his incision as follows ("Annals of Surgery," Jan., 1906):

"*For easy cases* the incision is made directly transverse, one and a half inches long. Its center is to be on the semilunar line on a level with the anterior-superior spine. The aponeurosis of the external oblique is divided in the line of the skin incision, but obliquely to the direction of its fibers. The fibers of the internal oblique and transversalis muscles are parted—not cut—in the same line as the structures above. The peritoneum is then opened and the incision carried inward through first the anterior layer of the sheath of the rectus. A blunt retractor three-quarters of an inch wide is then inserted and the muscle drawn toward the median line. This exposes the transversalis fascia and peritoneum posteriorly, which are then also divided. Thus is obtained a triangular opening with its base of three-quarters of an inch and two sides of about an inch long which is ample for simple cases.

For Difficult Cases.—If the case is a difficult one, the outer end of the incision is prolonged to the anterior spine or even above and inwardly through

the sheath of the rectus to within an inch of the median line. This will give an opening four to five inches long according to the size of the patient, sufficiently large to insert the hand if necessary and through which the appendix can be extracted under almost all circumstances."

After opening the peritoneum examine very gently to detect the situation

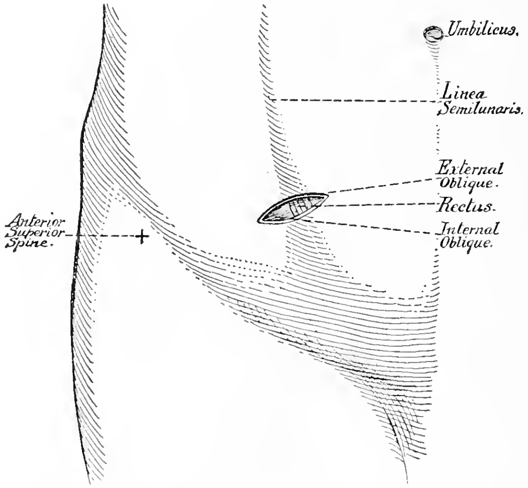


Fig. 456.—Davis's small transverse incision for simple cases.

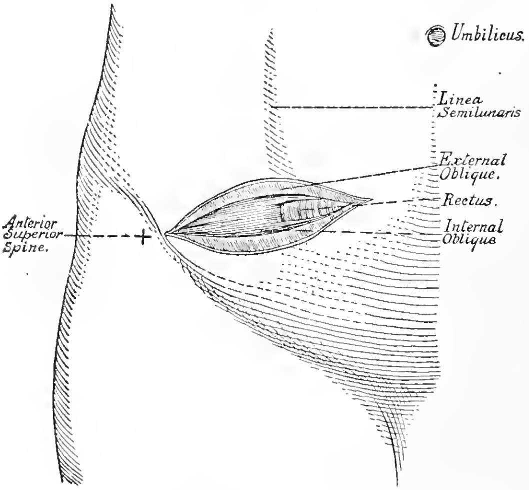


Fig. 457.—Davis's large transverse incision for difficult cases.

of the appendix, and if there are or are not adhesions. In a very recent case and in a very acute case there will probably be no adhesions unless there have been previous attacks. Surround the region of infection with strips of iodoform gauze, each strip being two and one-half inches wide, fifteen inches long, and four layers in thickness. The edges of the wound

should be lifted up by retractors and the strips inserted around the cut, between the parietal peritoneum and intestines and to a distance of three inches from the wound. Strips of gauze are passed, when possible, below the appendix to prevent entrance of infected material into the pelvis, and a piece is pushed upward toward the liver (Van Hook). Over the iodoform gauze which it may be necessary to leave in place after the operation gauze pads are packed. The appendix is sought for by finding the colon. The colon is found by following the parietal peritoneum with the finger. The course of the finger is first outward, next backward, and finally inward; the first obstruction it encounters is the colon. The fact that it is the colon can be confirmed by finding the longitudinal bands. The anterior longitudinal band leads directly to the appendix. Pass the finger down to the head of the colon, find the appendix, usually posterior and internal and lift it and the head of the colon into the wound. In some cases it will be advisable to deliver the head of the colon from the belly (Fig. 458); in other cases this will not be necessary. If adhesions exist, they must be gently and carefully separated. Barker's method (Fig. 460) is a very satisfactory mode of removing the appendix. It is

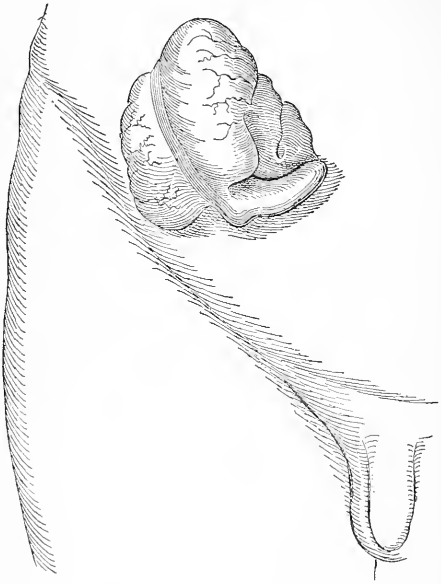


Fig. 458.—Radical operation for appendicitis (Kocher).

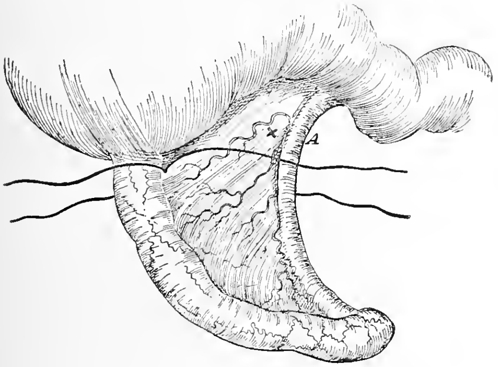


Fig. 459.—Ligation of appendix and meso-appendix.

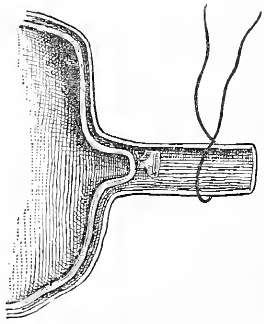


Fig. 460.—Barker's technic of operation for removal of the appendix.

done as follows: Turn up a cuff of peritoneum, pull down the other coats, ligate at the base, cut through the tube, let the musculomucous stump retract, and

tie or suture the peritoneal cuff over the stump. Another method, which is the one I usually employ, is as follows: Pass ligature through the meso-appendix as shown in Fig. 459, at *A*, tie the ligature, and cut off the meso-appendix below the threads, crush the stump of the appendix with strong straight hemostatic forceps. This divides the mucous membrane; ligate the appendix at the point shown in Fig. 459, tie it, and cut off the appendix between the ligature and a clamp. The stump beyond the ligature contains mucous membrane and muscle which are lifted out with forceps and scissors. Suture the fringe of the meso-appendix, and cauterize the stump of the appendix with pure carbolic acid and invert. Fig. 459 shows an older method still used by many. The meso-appendix is tied off by one ligature, the appendix is not crushed, but is tied off by another ligature, and both structures are cut off below their respective ligatures. The stump is cauterized and inverted and the fringe of the meso-appendix is sutured. This method does not entirely remove the appendix, but inverts glandular tissue into the wall of the bowel. The stump may not be completely asepticized by the carbolic acid and hence may lead to post-operative pain, abscess, dense adhesions, or fecal fistula, or the undestroyed lymphoid structure may cause future trouble, even persistent ill health (Joseph Price). Some remove the appendix by an elliptical incision around its base, and close the colon wound by Lembert sutures. This method, of course, removes the appendix completely. Dawbarn surrounds the appendix with a continuous Lembert purse-string suture of silk. This is inserted in the superficial layers of the cecum, half an inch from the appendix. The appendix is divided so as to leave a stump never shorter than half an inch. The lumen of the stump is gently stretched by inserting a pair of mouse-tooth forceps and opening the blades. The stump is then invaginated into the cecum—that is, it is turned "outside in." The sutures are tightened, and while this is being done, the mouse-tooth forceps used in effecting inversion are withdrawn. Finally, the sutures are tied (Robt. H. M. Dawbarn, in "Internat. Jour. of Surg.," May, 1895). The retained bit of appendix drains into the colon. If there is no pus or no extravasated feces, if the peritoneum is not seriously affected, if the appendix is not gangrenous or perforated, and if there is no pus within the appendix, remove the pads, irrigate with hot salt solution, remove the strips of gauze, and close the wound. If any of the above conditions were found, remove the infected pads, but leave the iodoform strips in place to limit infection and secure drainage. Pass sutures through the wound-edges, tie some of the sutures and leave some untied until the gauze is removed at a later period (Van Hook).

If an operation is performed in a distinct interval, pus is absent and the surgeon can proceed without apprehension. If there is any question of the presence of pus, surround the region with gauze, as suggested above, before breaking down adhesions and liberating the appendix. An interval operation should not be performed until three weeks after an attack. In an interval case McBurney proceeds as follows: He makes the skin incision in the direction of the fibers of the external oblique muscle, separates the fibers of this muscle by blunt dissection, retracts them, separates the fibers of the internal oblique and the transversalis muscles in the same way and retracts them, and opens the transversalis fascia and peritoneum. No muscle-fibers are cut, and hernia is not apt to follow. Such a wound is closed as follows: a continuous

catgut suture for the peritoneum, sutures of kangaroo-tendon for the transversalis fascia, the muscles are restored to place, the aponeurosis of the external oblique is sutured with kangaroo-tendon, and the skin is closed by a subcuticular stitch.

If an *abscess* is believed to exist, make an incision parallel with Poupart's ligament and over the area of dulness on percussion (Willard Parker's oblique incision). If the abscess is adherent to the anterior abdominal wall, such an incision will not enter the free peritoneal cavity. If, after opening the abdomen, an abscess is thought to exist, although it is not adherent to the anterior abdominal wall, surround the abscess with gauze before opening it, as directed under acute appendicitis. The gauze is placed under the margins of the incision in the peritoneum all around the appendix area; a piece is carried toward the pelvis and another piece toward the liver. Overlay this gauze with gauze pads (Van Hook). Adhesions are broken through with the finger, and when pus appears, it is at once wiped away. Remove the appendix in most cases, but not in all. If the appendix lies loose in the abscess-cavity, if it is sloughed off or but loosely attached to the abscess-wall, remove it. If the appendix is firmly fixed in the abscess-wall and must be dug out of a mass of inflammatory material, do not remove it. To remove it under these circumstances may rupture the wall and disseminate the pus into regions not protected by pads and gauze. Deaver and others tell us always to remove the appendix. I do not believe this to be a safe rule to follow. To insist on removing the appendix may cause death. When the appendix is left, it usually sloughs away. It is true a fecal fistula may result, but this is in the large bowel and usually heals spontaneously. Even if a fecal fistula forms and does not heal, the surgeon acted properly in not removing the appendix, because a fecal fistula may be remedied by another operation. It is rarely that secondary abscess forms, and there are not a great many cases recorded in which an appendix has subsequently given serious trouble when left after operation. In fact, in many cases the appendix is destroyed or obliterated by inflammation. In some cases, however, a secondary operation will be required because of a fecal fistula, a persistent sinus, or an acute inflammatory attack. When Deaver decides to remove such an appendix, he makes an incision in the median line of the abdomen, packs around the periphery of the abscess with gauze, opens the abdomen by another incision, removes the appendix, disinfects, inserts drainage, and then removes the surrounding gauze and closes the median incision. Irrigation should not be employed in appendicular abscess. The force of the stream may break down barriers of lymph and spread infection. After the evacuation of the pus, whether the appendix was removed or not, take out the pads, but leave the long strands of iodoform gauze in place (Van Hook). Introduce iodoform gauze into the abscess-cavity and insert a rubber tube, partially suture the wound, and dress with dry gauze. In forty-eight hours all the strands of gauze are removed and fresh pieces are inserted for drainage. After this period the gauze drain is changed daily. An interval case should be up and about in from ten days to two weeks after operation. An abscess case may require a much longer time for complete recovery. A fecal fistula sometimes results in cases in which the appendix was not removed, and occasionally forms when it was removed. Morris maintains and proves that these large pieces

of iodoform gauze sometimes cause intestinal obstruction and sometimes iodoform-poisoning, but the risk, it seems to me, should be taken.

If on opening the abdomen pus is found, unlimited by adhesions but wide-spread in the peritoneal cavity, remove the appendix, and then bear in mind Murphy's wise counsel as to how to treat general peritonitis (page 869). Put a drainage-tube in the pelvis, place the patient in Fowler's position, and administer salt solution by continuous proctolysis at a low pressure. The after-treatment of an ordinary appendix operation is advised after celiotomy (page 909).

Mortality after Operations for Appendicitis.—The interval operation is practically without mortality. In over 1000 cases Treves had 2 deaths. In acute cases the mortality is large. In 100 consecutive cases collected by Hearn and operated upon in the Jefferson Hospital by Keen, Hearn, and DaCosta, there were 8 deaths. As previously stated, Maurice H. Richardson reports a death-rate of 18 per cent. in 750 cases. Deaver reports from the German Hospital 144 cases with a mortality of 17.8 per cent. He eliminates one death from diabetes, one from pneumonia, and one from phthisis, and estimates his personal mortality at 15.9 per cent. (Deaver and Ross, in "Jour. Amer. Med. Assoc.," Oct. 5, 1901). In 124 cases (including all chronic cases and those acute cases in which the inflammation had not extended beyond the peritoneal coat) there was 1 death. The usual causes of death are intestinal obstruction, septic peritonitis, septic endocarditis, pylophlebitis, hepatic suppuration, metastatic abscesses, endocarditis, and gangrene of the bowel. In a further report from September 1, 1902, to September 1, 1903, Deaver reports 566 cases in the German Hospital, with an aggregate mortality of 5 per cent. In cases with diffuse peritonitis the mortality was 31 per cent. In abscess about a necrotic and perforated appendix it was 12 per cent. In early appendicitis or when disease was confined to the appendix it was 0.8 per cent.

Appendicostomy (Weir's Operation).—This operation was devised by Weir, of New York, in 1902. It consists in opening the abdomen, finding the appendix, fastening this structure to the skin, closing the rest of the wound, opening the appendix to see that it is patent, and applying a temporary ligature to prevent leaking. The temporary ligature is removed in a day or two, and a few days later the adherent and open appendix is used as a route for the introduction of irrigating fluids. The operation is of the greatest value in chronic ulcerative colitis, as it enables us thoroughly to irrigate the large bowel. Daily a large tube is passed into the rectum and a small tube into the appendix. The fecal matter is washed out of the bowel with salt solution, and then a 1 : 5000 solution of silver nitrate or bismuth and starch water (ʒj to the ℥) is used to irrigate. It is used for the same purpose in some cases of tuberculous rectal or anal fistulæ. A most extraordinary suggestion is that appendicostomy be performed in epileptics, so that the opening may be used to flush the bowel, a suggestion which I will not act upon. When the fistula exists, it does not leak to any appreciable degree. When we wish to close it, we insert within the lumen of the tube the Paquelin cautery at a red heat. This destroys the mucous membrane and the fistula closes (Robt. Weir in "Med. Record," August 9, 1902).

Enterorrhaphy, or Suture of the Intestine.—Surgical opinion has

greatly altered in regard to this operation since the day when John Bell wrote his famous attack on Benjamin Bell. John Bell said: "If in all surgery there is a work of supererogation, it is this operation of sewing up a wounded gut." To-day we know that if in all surgery there is a proceeding of imperative necessity, it is the sewing up of a wound in the intestine. To perform this operation take fine sterile silk and thread a thin, round, straight, calyx-eyed

Fig. 461.—Eye of the calyx-eyed needle.

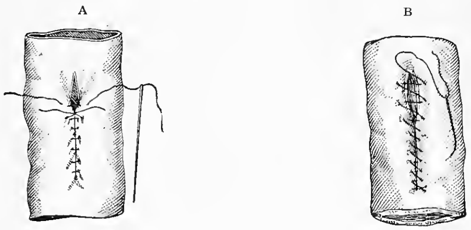


Fig. 462.—Enterorrhaphy: A, Lembert's suture; B, Dupuytren's suture.

needle with it (Fig. 461). This needle is very useful, as it can be threaded rapidly by pushing the calyx eye down upon the silk thread while the latter is kept taut. *Lembert's suture* (Figs. 462, A, 468, and 469) was devised in 1823. Lembert used it on animals, but never on man. It is inserted at right angles to the wound. It goes down to, but not through, the mucous membrane. It is formed by picking up a fold of the intestine (one-twelfth to one-

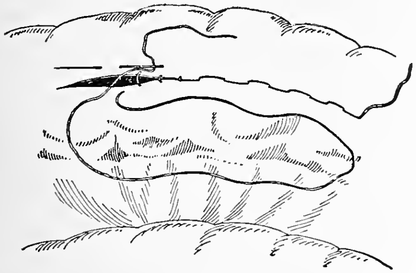


Fig. 463.—Cushing's right-angled suture (Senn).

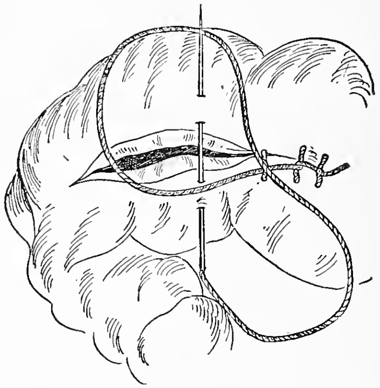


Fig. 464.—Ford's stitch, showing a Lembert insertion and the needle passed so as to tie a single knot by drawing it on through.

eighth of an inch wide) one-eighth of an inch from the edge on one side of the wound, passing the needle through, picking up a fold on the opposite side of the wound, and passing the needle through. On tying the threads the serous membrane is inverted and peritoneum is brought into contact with peritoneum. For many years it was taught that this suture should include only the serous coat, but Halsted, in 1887, showed that it must include the tough submucous

coat. The submucous coat is strong, and will hold a suture. The other coats are thin, tear easily, and will not hold a suture. So thin are the coats that a surgeon could not suture the serous coat alone were he to try. Sutures which include only the muscular and serous coats tear out easily. *Dupuytren's suture* (Fig. 462, B) is simply a continuous Lembert suture running obliquely across the wound. *Cushing's right-angled suture* (Fig. 463) is a continuous suture catching up the submucous coat and serving to invert the serous layer. Ford, of San Francisco, employs a continuous inversion suture, which is tied in a single knot each time it is drawn through (Fig. 464). Downes, of Philadelphia, uses a similar stitch. Halsted's mattress or quilt suture is shown in Fig. 465.

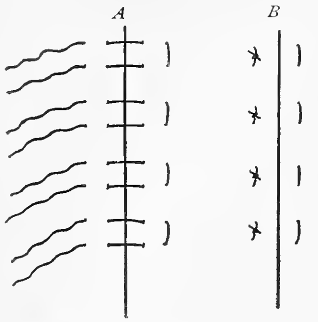


Fig. 465.—*A*, Halsted sutures untied; *B*, Halsted sutures tied and serous surface inverted.

Each stitch picks up the submucous coat. Mattress sutures do not tear out easily, they appose evenly considerable surfaces, and do not constrict the tissue as much as Lembert stitches. The *Czerny-Lembert suture* is a suture passed through the serous membrane on one side of the wound, made to perforate the mucous membrane, and to emerge at a corresponding point of the serous membrane. A Lembert suture is added (Fig. 466). As at present used, the Czerny suture is carried to, but not through, the mucous membrane. Gussenbauer's suture is similar to the Czerny-Lembert suture, except that it applies the Czerny and the Lembert with one suture, and this suture does not pass through the mucous membrane (Fig. 467). In *Connell's suture*

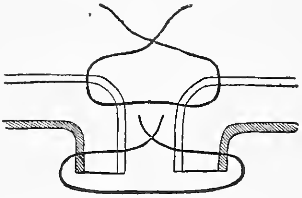


Fig. 466.—Czerny-Lembert suture.

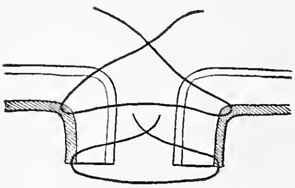


Fig. 467.—Czerny-Lembert suture as at present used.

(F. Gregory Connell, in "Phil. Med. Jour.," Jan., 1899) the knots are placed within the lumen of the bowel (Plate 10). Connell's very useful and ingenious stitch seems to be a modification of a stitch described by Frederick Holme Wiggin ("Med. Record," Nov. 19, 1898). *Wölfler's suture* unites broad layers of the serous coat, the knots being tied internally (Fig. 470). Senn says that after suturing a large wound of the stomach or of the intestine a strip of omentum ought to be laid over the wound and fastened by catgut sutures (*omental graft*). These grafts adhere and are a safeguard against leakage. (For other methods of enterorrhaphy see Intestinal Resection and Anastomosis.)

Operations upon the Stomach.—A patient must be carefully pre-

EXPLANATION OF PLATE 10.

Intestinal suture, all knots inside (Connell).

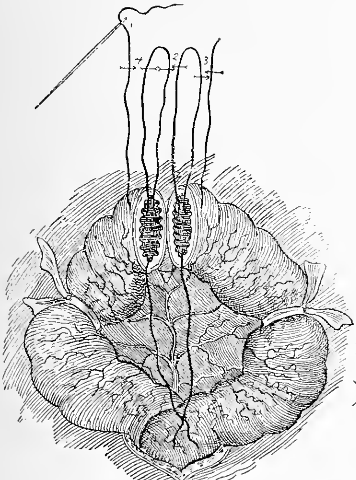
a, Suspending loops 2, 3, and 4 are made with one thread inserted at a point two thirds of the distance from mesenteric to convex border. The needle with suture is passed through the four walls of the cut ends, and that portion of suture within each lumen is drawn up to a sufficient length, then cut, and the contiguous threads tied at the points indicated by the arrows; thus having as a result four suspending loops dividing the circumference of each cut end into thirds. Instead of employing four suspending loops which divide the circumference of the bowel into thirds, we may use but two loops, and thus divide the circumference into halves; or, if available, the "holder" devised by Dr. E. H. Lee can be recommended highly, and will be found a most efficient aid in maintaining the cut edges in apposition. (The description of the instrument will be found in the "Annals of Surgery," January, 1901.)

b, Loop 2 has been cut away, and loop 1 takes its place in one hand of the assistant, with loops 3 and 4 held in the other hand, thereby bringing into apposition that portion of the walls to be included in the second third of the suture. The operator continues the suture to the points of insertion of loops 3 and 4, where again a back stitch is taken, to fix the suture and prevent a purse-string contraction of the same. The white elevation in the center of illustration, representing mesentery, shows that that portion of the intestinal wall not covered by peritoneum, at the mesenteric border, has been secured in the suture.

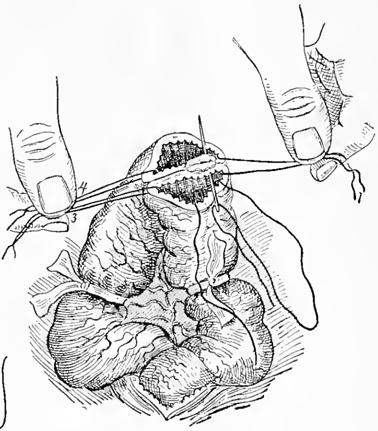
c, The needle, after having entered the lumen, is passed out again on the same side $\frac{1}{8}$ inch distant; then over to the opposite cut end, where it is inserted from without in, and again emerges from within out, on the same side. This step—the taking of a bite —is repeated alternately on opposing margins until the necessary number of stitches have been inserted. It will be observed that when the needle enters the lumen the last time, it makes what might be termed a half-stitch, as it does not return again *through* the wall; but having reached the point where the suture was commenced, the free end and the needle end will complete the last stitch, when tied, on the mucosa. The needle at this point is then brought out of the lumen at the angle of wound alongside of the free end of the suture. The cross-over stitches are next carefully drawn up, thus bringing into contact the opposing serous surfaces at every point except where the suture ends still protrude.

d, The eye-end of threaded needle is made to emerge alongside of the suture ends, and is then withdrawn a little, which causes its thread to form a loop, through which the assistant passes the ends of the suture. The operator next withdraws the threaded needle, at the same time bringing with it the suture ends, and they present externally at the point of withdrawal of the needle. The serous coats throughout the entire circumference are now in apposition, and the suture ends can be tied.

e, By slight traction on the suture ends the opposing mucous surfaces are brought in close contact; the suture ends are then tied firmly, and deep between the serous coats, thus tying the knot upon the mucous coat, and the ends then cut off short.



a



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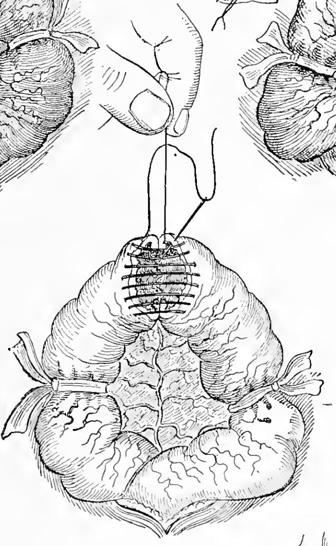

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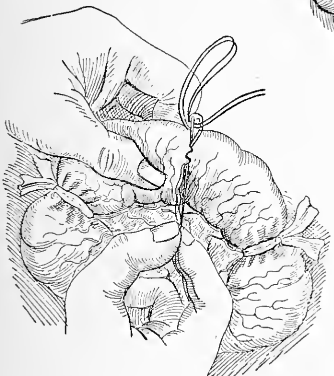
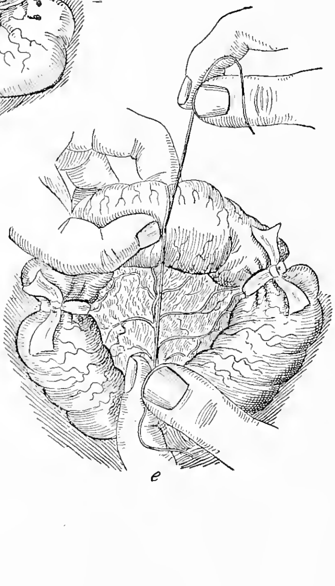


d



e

pared for an operation upon the stomach. The Johns Hopkins method, founded on the researches of Harvey Cushing regarding sterilization of the stomach, is to be used. During the two or three days immediately preceding operation clean the mouth and teeth several times during the day with a carbolic solution. Give only sterile water and sterile liquid food by the mouth, and for twelve hours before operation give no food whatever. During the

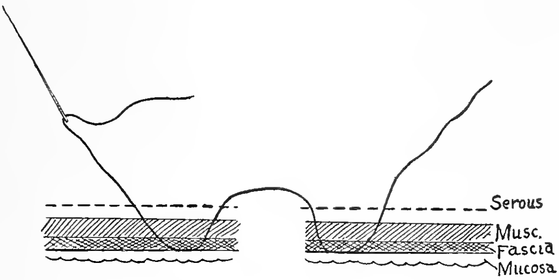


Fig. 468.—Lembert's suture.

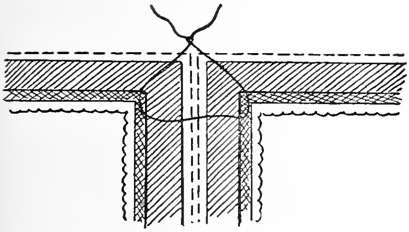


Fig. 469.—Lembert's suture closed.

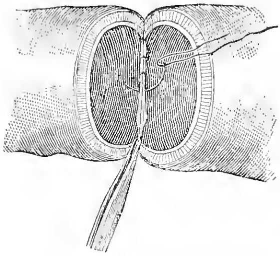


Fig. 470.—Wölfler's suture.

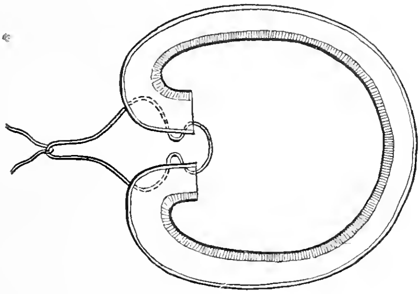


Fig. 471.—Gussenbauer's suture.

two or three days before operation wash the stomach with boiled water night and morning. I do not wash immediately before operation, as it sometimes leads to annoying vomiting and thus may interfere with anesthetization. After operation give no food whatever for thirty-six or forty-eight hours. A little hot water is given early. During the first twenty-four hours give an enema of hot salt solution and coffee every five hours and then alternate nutritive enemata with salt enemata. After thirty-six or forty-eight hours

usually begin to give food—at first small doses of albumin-water, and, if this is tolerated, broth and milk (Finney, in "Johns Hopkins Hosp. Bull.," July, 1902). Solid food should not be given for three weeks.

Digital Dilatation of Pylorus for Cicatricial Stenosis (Loreta's Operation).—Place the patient recumbent and administer ether. Make a vertical incision in the linea alba or through the right rectus muscle. The median incision begins one inch below the ensiform cartilage. The cut in either case should be five inches in length. When the peritoneum has been opened, the stomach is drawn out of the wound, any adherent omentum is separated, and the pylorus is carefully examined. The stomach, after being surrounded with gauze pads, is opened near the center of its anterior surface, "but rather nearer to its pyloric end" (Jacobson).

Insert the index-finger through the stomach wound and into the pylorus, and follow that with the middle finger. The pylorus can be well dilated by separating the fingers. If the stenosis is so tight as to prevent the entry of a finger, first introduce a pair of hemostatic forceps and open the blades a little when they are within the lumen of the constricted area. The wound in the

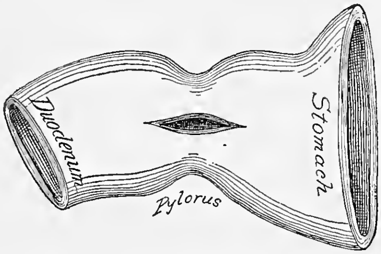


Fig. 472.—Heineke-Mikulicz's pyloroplasty: the incision.

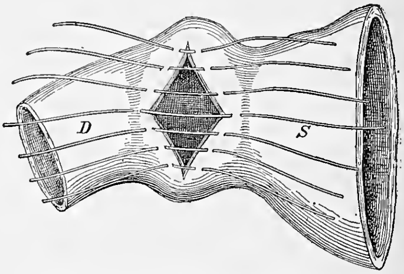


Fig. 473.—Heineke-Mikulicz's pyloroplasty. The axis of the incision is changed by traction from horizontal to vertical; sutures in position; only one of the two rows of sutures is shown.

stomach is closed by a continuous silk suture of the mucous membrane and two layers of Halsted sutures, to invert and approximate the peritoneal surfaces. After closure of the stomach wound the abdominal wound is sutured.

Divulsion by the fingers or by an instrument is no longer practised, because experience has shown that the constriction is sure to return.

Pyloroplasty (Heineke-Mikulicz Operation).—The first operation was performed by Heineke in 1886. Early in 1887 Mikulicz, not knowing of Heineke's antecedent operation, did the same thing. Open the abdomen in the middle line, or, better, through the right rectus muscle. Draw up the pylorus as well as possible, and pack warm moist gauze pads around it; make an incision through the stricture and in a direction corresponding to the long axis of the stomach and bowel (Fig. 472). Catch an aneurysm-needle under the upper margin of the incision and draw it up, and an aneurysm-needle under the lower margin and draw it down. The effect of traction is to convert the transverse wound into a vertical one. The sutures are applied so as to maintain the wound in a vertical line (Fig. 472). The mucous membrane is sutured with a continuous suture of silk, and interrupted Lembert or Halsted

sutures of silk close the peritoneal and muscular coats (Figs. 473 and 474). Drain for twenty-four hours, because there is danger of leakage. A. W. Mayo Robson inserts a bone bobbin and then applies the sutures. The operation of pyloroplasty shows a mortality about the same as or slightly less than gastro-enterostomy. In some cases it is a very satisfactory procedure, but there are objections to it, and in 30 per cent. of cases it fails to give relief (Wm. J. Mayo). The outlet is not at the most dependent part of the stomach, hence the stomach may not empty itself. Further, as Finney points out, it cannot be performed if there are firm adhesions or active ulceration, and the scar may contract and give rise to stenosis. Again, it is difficult to suture so as certainly to provide against leakage. The Mayos reported 21 pyloroplasties without a death, but 7 cases required secondary operations ("Annals of Surgery," Nov., 1905). Pyloroplasty has been generally abandoned. Finney has devised an operation to correct the objections to pyloroplasty.

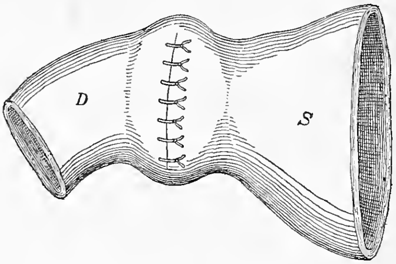


Fig. 474.—Heineke-Mikulicz's pyloroplasty: after tying the sutures.

Gastro-duodenostomy by Finney's Method.—This operation is usually called a method of pyloroplasty, but it is rather a gastro-duodenostomy.

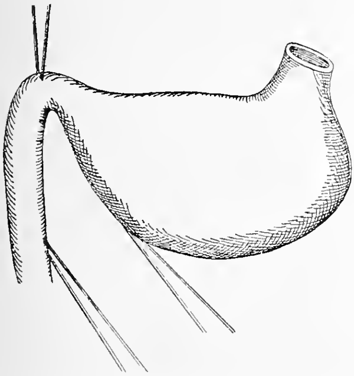


Fig. 475.—Finney's pyloroplasty. The retractor sutures.

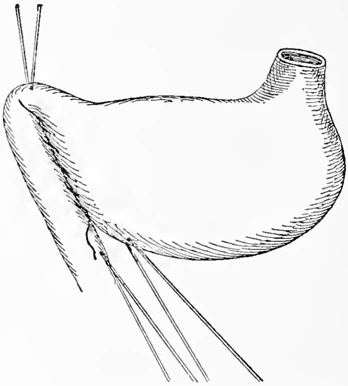


Fig. 476.—Finney's pyloroplasty. Suture of greater curvature of stomach to duodenum.

This excellent operation was described in the "Johns Hopkins Hospital Bulletin," July, 1902, and was then called pyloroplasty. It is performed as follows: Thoroughly free the first portion of the duodenum and the pyloric end of the stomach. Insert three retractor sutures (Fig. 475) and draw upon them. Suture together, as far posterior as possible, the peritoneal surface of the duodenum and the peritoneal surface of the stomach, along its greater curvature (Fig. 476). Insert an anterior row of mattress sutures, but do not tie them as yet (Fig. 477). Make

a horseshoe-shaped incision (Fig. 478); arrest bleeding; excise as much scar-tissue as possible on either side of the incision, and trim off the redundant mucous membrane. Insert a continuous catgut suture on the posterior side of the incision and carry it through all the coats (Fig. 479). Straighten out the anterior sutures and tie them (Fig. 480). The Mayos report 58 Finney operations with 1 death and 2 secondary operations (Wm. J. Mayo in "Annals of Surgery," Nov., 1905).

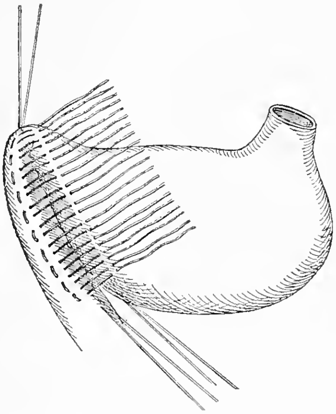


Fig. 477.—Finney's pyloroplasty. Shows the three retractor sutures, the posterior line of sutures tied and the anterior line of sutures untied.

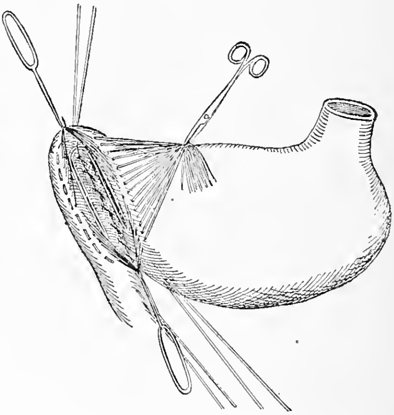


Fig. 478.—Finney's pyloroplasty. The anterior sutures gathered and lifted.

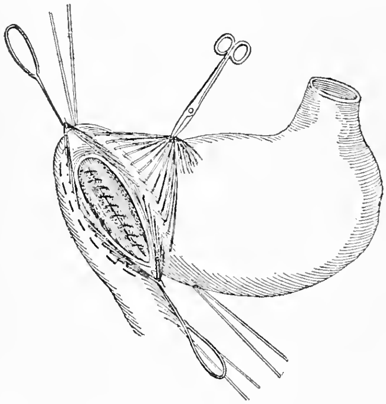


Fig. 479.—Finney's pyloroplasty. The continuous posterior catgut suture.

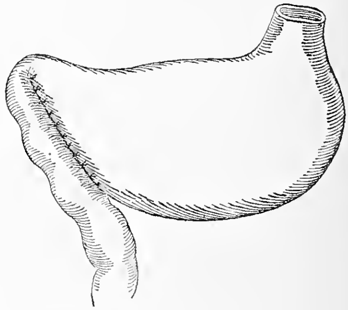


Fig. 480.—Finney's pyloroplasty completed by tying the anterior sutures.

Pylorectomy (Excision of the Pylorus).—The removal of a portion of the stomach is a partial gastrectomy, and pylorectomy is a partial gastrectomy in which the pylorus and also a portion of duodenum are removed.

This operation was first performed by Péan in 1879. It was next performed by Rydygier in 1880. Billroth did the first successful pylorectomy in 1881. The operation is usually performed for cancer, but sometimes for pyloric ulcer and its results. In many cases of pyloric cancer the abdomen

is opened after a palpable tumor is detected, and when a palpable tumor is detectable it is usually too late to perform pylorectomy.* The lesson is to explore suspected cases earlier than has been our custom.

Keen agrees with Hemmeter that stenotic symptoms, even when no tumor is palpable, call for exploratory laparotomy; if the stomach is dilated, if there is cachexia, if there is no free hydrochloric acid in the gastric juice, if there is

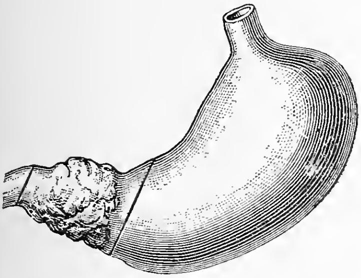


Fig. 481.—Billroth's method of pylorectomy.

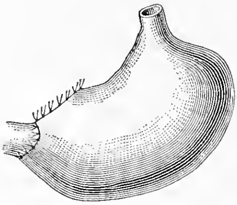


Fig. 482.—Pylorectomy.

an excess of lactic acid in the gastric juice, if the patient is at or beyond forty years of age, when there is vomiting of blood, when the Oppler bacillus is present, when blood examination shows a diminution in red corpuscles and hemoglobin, and also shows that there is no increase in white corpuscles after a full meal. After the abdomen has been opened the stomach is examined, and if a tumor exists, the surgeon must decide between the performance of pylorectomy and gastro-enterostomy. If the tumor is not very extensive, if there is no glandular involvement or only involvement which can be removed, and if adhesions are not extensive, pylorectomy is chosen; otherwise gastro-enterostomy is selected.

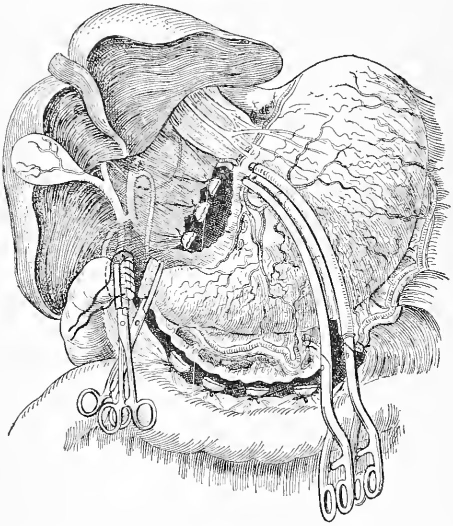


Fig. 483.—Pylorectomy by the Mayo method. Clamps applied, duodenum divided, and continuous catgut stitch introduced (Mayo).

Until very lately the mortality from pylorectomy was estimated to be 25 per cent., even in favorable cases. In 9 complete pylorectomies, with closure of both the stomach and duodenal ends, communication being reëstablished by the performance of gastrojejunostomy, Mayo reports 1 death, and in 14 pylorectomies and partial gastrectomies he reports 2 deaths, or 14 per cent. (Wm. J. Mayo, in "Annals of Surgery," Aug., 1902). Prepare the patient for pylorectomy as

* Keen's "Cartwright Lectures" for 1898.

for any stomach operation. The best incision through the abdominal wall is a vertical one in or by the median line. A small incision is made first to permit of exploration, and if the growth is found to be removable, the incision is enlarged. In some cases it will be found necessary to divide the rectus muscle by a transverse cut.

Method of the Mayos.—This is the best operation. The Billroth method, which was long employed, does not remove enough of the stomach in a case of malignant disease, the opening left in the stomach is much larger than the duodenal opening, and in suturing so as to make the two openings of equal size an angle is left which is apt to leak. Billroth's operation is shown in Figs. 481 and 482. In Mayo's method after exposing the stomach ligate the gastric artery close to the stomach, tie the lesser omentum in several segments close to the liver and divide it, and tie the pyloric artery. Apply two clamps to the duodenum and have them 1 inch apart, and divide the duodenum by means of the cautery (Fig. 483).

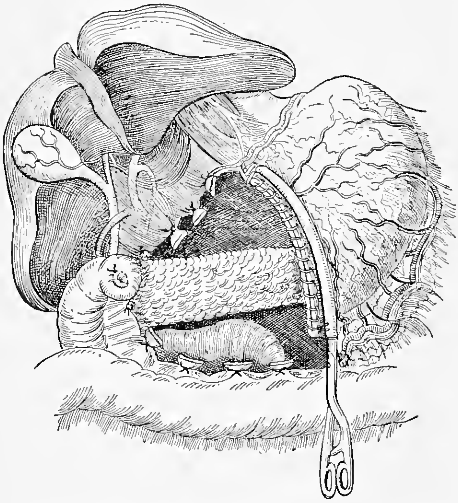


Fig. 484.—Pylorectomy by the Mayo method. End of divided duodenum buried by a purse-string suture. Row of lock stitches inserted in stomach stump (Mayo).

Close the right end of the duodenum by means of a continuous catgut suture, remove the clamp, and invert the closed end by a purse-string suture (Fig. 484). Pass a hand from above back of the stomach and lift the great omentum forward. Tie the right gastro-epiploic artery close to the stomach. Tie the left gastro-epiploic artery distinctly to the left of any enlarged glands in the great omentum. Tie the great omentum in several segments. Divide the great omentum, leaving any enlarged glands attached to the portion of the stomach it is the intention to remove. The stomach is to be divided to the left of all lymphatic glands into which the cancerous region drains. The clamps are applied as shown in Fig. 483. The stomach is divided between the clamps with a cautery, and as the division is being carried out catch the stump here and there with hemostatic forceps to prevent it slipping through the clamps. Slipping is disastrous and will cause leaking and entrance of air into the stomach, and entrance of air is apt to be followed by pulmonary difficulty.

A row of locking stitches are passed through all the coats of the stump and tied, and a second row is also passed and tied (Fig. 484). The clamp is removed and the stump is buried by Cushing's right-angled suture or Dupuytren's suture. A gastro-jejunostomy is then performed to the posterior wall of the portion of stomach which remains.

Such a patient is usually much dehydrated, and, if he is, salt solution should

be given intravenously during the operation, and an enema of warm salt solution should be administered every 6 hours for several days after the operation. Active stimulation is usually necessary and 8 ounces of coffee should be given by rectum at the completion of the operation. The patient must be placed recumbent as soon as the effects of the ether pass away. Twelve hours after operation begin to give small amounts of hot water by the mouth. Nourish by the rectum from 4 to 6 days, when fluid food may be given by the mouth, starting with small doses of albumin water, and if this is tolerated, giving dessertspoonful doses of peptonized milk every hour.

Total Gastrectomy.—The entire stomach was first removed by Conner, of Cincinnati. The first successful operation was performed by Schlatter, of Zürich, in 1898. Total gastrectomy will rarely be required, but in certain unusual cases it will be proper to perform it. In some cases the duodenal end can be sutured to the divided esophagus; in others it will be necessary to close the end of the divided first portion of the duodenum, and anastomose the esophagus to the third portion of the duodenum.

The cases suitable for total gastrectomy are those in which the entire viscus, or almost the entire viscus, is cancerous, the stomach being still freely movable, and the glands not so much implicated as to forbid attempts at removal. It is a remarkable fact, first demonstrated in Schlatter's case, that an individual can digest food very well without a stomach. This statement is true only if stomach function has been gradually abolished by disease. During this period the functions of the stomach have been assumed to a greater or less degree by other parts. In a recent injury of the stomach complete removal would almost certainly be followed by death, as other parts have had no chance to learn how to assume gastric duties. The reported cases of total gastrectomy show a mortality of 33 per cent., but, as Robson truly says, if all cases were reported, the mortality would be found to be 50 per cent.

Gastrotomy.—This term is used to designate the operation of opening the stomach for the accomplishment of some purpose, and immediately closing the incision in the gastric wall when that purpose is accomplished. Gastrotomy may be performed to permit of the removal of foreign bodies, of exploration of the stomach and its extremities, of divulsion of the pyloric orifice, of the treatment of bleeding, of an esophageal stricture, or a stricture of the cardiac orifice of the stomach, or of the removal of a foreign body lodged in the esophagus. The first successful case on record was that of Shoval in 1635.

The patient is prepared as for pylorectomy. The incision may be vertical in the middle line or identical with the incision for pylorectomy. If a large foreign body can be felt, the incision is made directly over it. When the peritoneal cavity is opened, the surgeon decides as to the point where the stomach is to be incised, and draws this portion out through the wound, packing gauze pads under and around it. The stomach is opened by means of scissors, the cut being at a right angle to the long axis of the viscus (Jacobson). Bleeding vessels are ligated with catgut. The purpose for which the stomach was opened is now to be carried out, the interior of the stomach and the surface of the extruded portion are irrigated with hot salt solution,

the mucous membrane is sutured with a continuous suture of silk, and two rows of Halsted sutures are inserted. The abdominal wound is closed, drainage being employed for twenty-four hours.

Gastrostomy is the making of a permanent gastric fistula, through which opening the patient can be fed. Gastrostomy was first proposed by Egebert in 1837 (Keen), and was first performed by Sédillot in 1849. In 1875 Sydney Jones operated upon the twenty-ninth case and obtained the first recovery (Keen). Up to 1884 the estimated mortality was 80 per cent. At present the mortality in malignant cases is from 20 to 25 per cent., and in non-malignant cases from 8 to 10 per cent. Gastrostomy is employed in cases of esophageal obstruction or obstruction of the cardiac end of the

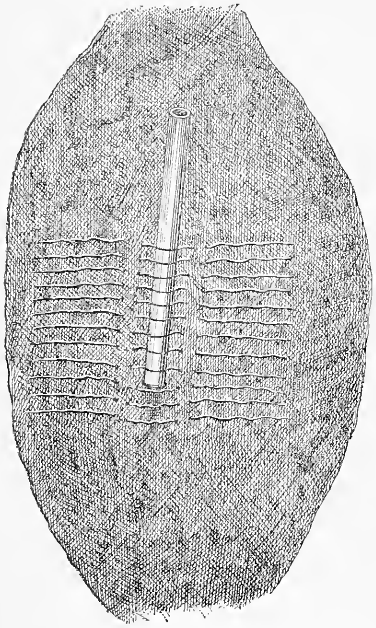


Fig. 485.—Witzel's method of gastrostomy, showing application of sutures in wall of stomach, embedding tube obliquely therein.

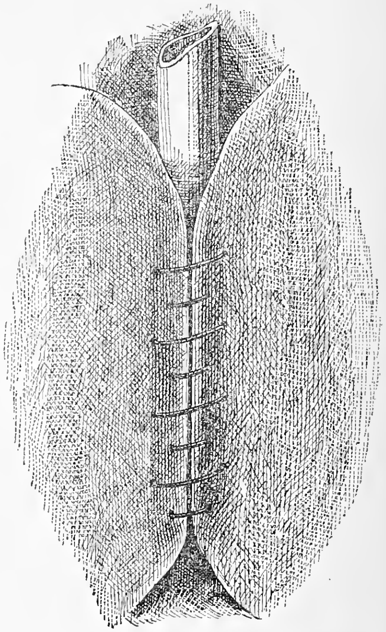


Fig. 486.—Sutures tied, completely embedding tube obliquely therein.

stomach. In many cases of malignant disease the operation is performed too late, and if performed when the patient is greatly emaciated and exhausted, the operation has, of course, a high mortality. An early operation is far safer and confers the maximum of relief. The operation should be performed, as Mikulicz advises, when the patient is steadily losing weight and there is beginning to be difficulty in swallowing semisolids or liquids. The surgeon must endeavor to perform an operation which will not permit of leakage. Prepare the patient as for any stomach operation.

Witzel's Method.—This operation was first practised in 1891. An incision is made four inches long, running to the left from the middle line, just below the border of the ribs. After opening the peritoneal cavity seize the stomach,

bring it out of the wound, and pack gauze around it. Introduce a rubber tube into the stomach and enfold it by a double row of Lembert sutures (Figs. 485, 486). This tube should be five inches long and of the same

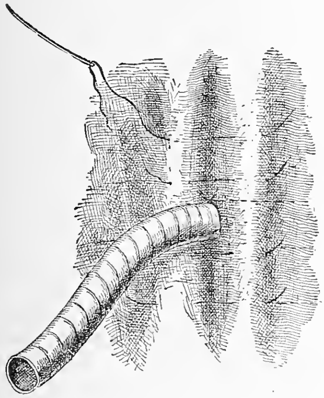


Fig. 487.—Kader's method of gastrostomy. Tube in place and first row of sutures inserted.

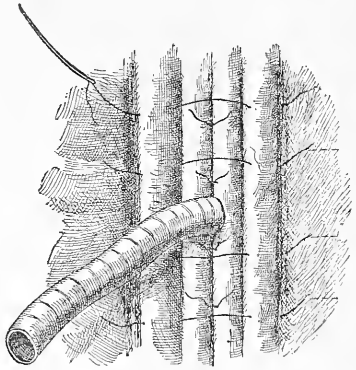


Fig. 488.—Kader's method of gastrostomy. First row of sutures tied and second row inserted.

diameter as a No. 25 French bougie. The opening is made in the stomach toward the cardiac extremity, the tube is placed parallel with the belly-wound, and the outer end of the tube emerges in the median line. The tube is retained in place by a catgut stitch carried through the tube and the stomach-wall. The stomach is returned and is stitched by three sutures to the abdominal wall. The abdominal incision is sutured and a clamp is placed on the tube. When the patient is fed, a funnel is slipped into the tube, the clamp is removed, and liquid food is poured into the funnel. After the wound heals it is not necessary permanently to retain the tube. It is passed when the patient desires food.

Kader's Method.—This operation was devised in 1896. It is a modification of Witzel's method. A small incision is made in the stomach and a tube is introduced and fastened to the stomach by one catgut stitch. Four Lembert sutures are passed so as to form a fold on each side of the tube and turn the stomach-wall inward around the tube (Fig. 487). Lembert sutures are inserted in the furrow on each side of the tube. Two more folds are formed over the first two (Figs. 488 and 489). The stomach-wall is stitched to the parietal peritoneum and sheath of the rectus muscle (Willy Meyer).

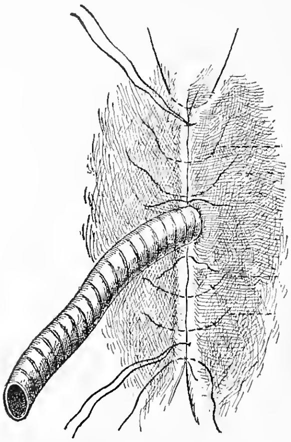


Fig. 489.—Kader's method of gastrostomy. Second row of sutures tied.

The Ssabanejew-Frank Method.—This operation is preferred by many

surgeons. I usually employ it if the stomach is not so shrunken as to render the pulling out of a sufficient cone impossible. It was first performed by Ssabanejew in 1890 and was performed independently by Frank in 1893. Fenger's incision is made (a curved incision at the margin of the costal cartilages of the left side). A cone of the stomach is pulled out of the wound and is passed under a bridge of skin which has been prepared for it. The stomach is fixed above the margin of the ribs and opened (Figs. 490, 491). Von Hacker makes the gastric fistula through the left rectus muscle, and Hahn between two of the rib cartilages (Willy Meyer).

The Younger Senn's Method.—Emanuel Senn devised the following method: A cone of the stomach is pulled out of the abdominal wound, and this cone is puckered by the insertion of two drawing-string sutures of chromicized catgut through the serous and muscular coats. A cuff of gastrocolic omentum is sutured by silk around the neck of the puckered cone. The stomach

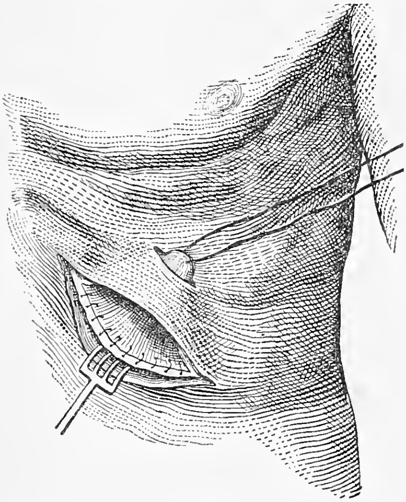


Fig. 490.

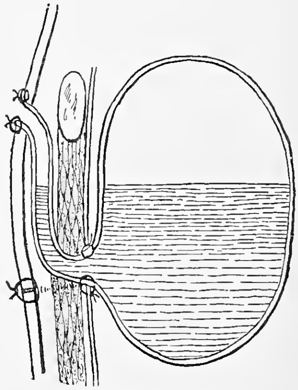


Fig. 491.

Figs. 490, 491.—The Ssabanejew-Frank method of gastrostomy in carcinoma of the esophagus.

is sutured to the belly-wall with silk, the sutures including the omental cuff, the serous and muscular coats of the stomach, and the structures of the belly-wall, except the skin. The skin is partly sutured. The stomach may be opened at any time.

Gastro-enterostomy or **gastro-jejunostomy** is the establishment of a permanent fistula between the stomach and the small intestine, in order to side-track the pylorus. The operation is performed for cancer of the pylorus, for non-cancerous stenosis of the pylorus, in some cases of ulcer of the stomach, and for tetany. Anterior gastro-enterostomy was proposed by Nicoładoni in 1881 and was first performed by Wölfler the same year. Posterior gastro-enterostomy was first proposed by Courvoisier in 1883. His plan necessitated a transverse division of the mesocolon, but it was found that this impaired the blood-supply of a part of the colon and might lead to gangrene. Von Hacker, in 1885, devised the method we now practise. As

a matter of fact, the transverse mesocolon has a marginal artery, unlike other parts of the colon, and the danger of gangrene from a transverse incision is probably not very great. In the earlier operation the mortality was 40 per cent. In non-malignant conditions the mortality is very low (under 3 per cent.), the hyperacidity of the gastric juice disappears, and the functions of the stomach are restored. In malignant cases the mortality is about 20 per cent., but even in such cases, if operation is done early, life may be prolonged and made comfortable for months. Wm. J. Mayo makes the following report upon 421 cases of gastro-jejunostomy. "Benign, 307 cases, 19 deaths ($6\frac{1}{2}$ per cent.). In the last 140 there were 4 deaths, a mortality of $2\frac{6}{7}$ per cent.; the last 80 gave but 1 death. One hundred and fourteen malignant, with 21 deaths (18 per cent.). Of these 114 cases, 63 were in connection with pylorectomy and partial gastrectomy, with 8 deaths (13 per cent.). The very unfavorable cases of cancer obstruction were subjected to gastro-enterostomy, so that this operation gives a higher mortality than radical excision. In the last 40 gastro-jejunostomies for malignant disease the mortality was 8 per cent. In the 421 gastro-jejunostomies there were 21 reoperated cases (5 per cent.)." ("Annals of Surgery," Nov., 1905.) In about 5 per cent. of cases of gastro-enterostomy for benign disease secondary operation has been required. In Krönlein's clinic, 51 cases of malignant disease subjected to gastro-enterostomy showed an average duration of life of 192 days; 470 days after operation 17 cases were living. The causes of death, according to Mayo, are: exhaustion, exhaustion with vomiting, pneumonia, and detachment of the anastomosed intestine.

Treatment After Gastro-enterostomy.—On returning the patient to bed at once establish continuous enteroclysis with one-half strength salt solution, the reservoir being only 6 inches above the level of the bed. This is Murphy's plan. As soon as patient is out of ether place him semi-erect. Mayo begins in from sixteen to twenty hours to administer by the mouth one ounce of hot water every hour, and if it is well tolerated, it is quickly increased, and in thirty-six hours liquid food is given and if tolerated, is continued.

Complications Following Gastro-enterostomy.—Among them are *lung complications*. These are not due to the anesthetic, for they tend to occur even when local anesthesia was employed. They are not due to the epigastric incision interfering with cough and expectoration, for they are not nearly so common after operations upon the gall-bladder (Wm. J. Mayo). Mayo says that the latest theory is that some of the venous blood returning from the stomach does not pass through the liver, and infected emboli are deposited in the lungs. The *suture line* may *leak* after gastro-enterostomy, because of imperfect suturing, or the anastomosed intestine may become *detached*. Twenty per cent. of the deaths among Mayo's cases resulted from this cause. *Contraction* of the *anastomosis opening* may gradually take place. This has been held by some to be particularly common in cases of dilated stomach, shrinking of the stomach being the efficient cause; but evidence upon this point is not conclusive. In cases in which the pylorus is not obstructed shrinking often occurs, but it rarely takes place when the pylorus is obstructed. In some cases, after operation a *spur* forms in the jejunum because of angulation; in other cases adhesions produce obstruction; and in rare instances ulceration takes place in the jejunum.

The most common complication after gastro-enterostomy is *persistent vomiting*, which may or may not be expressive of the formation of a vicious circle.

Ulcer of the Jejunum.—Thirty-one cases have been reported (A. Gosset, in "Révue de Chirurgie," Jan. and Feb., 1906). Most of the reported cases, it is found, suffered from non-malignant trouble and had hyperacid gastric juice. It very seldom occurs after operations for cancer. Most of the reported cases happened after the anterior operation and when the anastomosis was very near to the pylorus. It does happen, however, after the posterior operation, and cases have been reported following both the anterior and posterior methods associated with entero-anastomosis. It is probable that more cases seem to follow the anterior method because until late years it has been the operation commonly performed. In most of the reported cases the ulcer was single, in 3 it was multiple. It is usually in the distal loop, but may be in the proximal loop. It may be situated at the anastomosis level, a little way below it, or even 5 or 6 inches below it. The ulcer may appear a few days after the operation, weeks after, months after, or even years after. The condition results from hyperacid gastric juice passing directly into the jejunum before it has been neutralized by admixture with bile and pancreatic juice.

The Vicious Circle and Regurgitation.—Vomiting may occur after the performance of gastro-enterostomy. It may soon cease, may be productive of disastrous consequences, and may be expressive of an existing complication of great gravity. In some cases of gastro-enterostomy vomiting arises because the anastomosis has been made high up on the anterior wall and the stomach is not drained. In other cases ether induces vomiting, and the mechanical efforts force the contents of the duodenum and even of the jejunum into the stomach. The true "vicious circle" is a condition in which the contents of the stomach pass through the anastomosis opening into the duodenal side of the loop of intestine, mix with the duodenal secretions, and return to the stomach (Fowler, in "Annals of Surgery," Nov., 1902). The following conditions are often classified under the same head, but each is called by Fowler a regurgitation or reflex: (1) When the duodenal secretions pass back into the stomach through a permeable pylorus (as in cases of gastroptosis, non-cancerous pyloric stenosis, and gastric dilatation); (2) when the duodenal secretions enter the stomach through the anastomosis opening; (3) when the contents of the jejunum pass into the stomach, because of efforts at vomiting or as a result of reversed peristalsis. In some cases the contents of the jejunum may pass into the afferent loop of intestine and distend it.

Persistent vomiting may be due to spur formation which deviates stomach contents into the duodenal side of the loop. It is in some cases due to kinking or twisting of the distal loop; in others, to failure of peristalsis in the proximal loop; in still others, to contraction of the opening in the stomach-wall (Chlumsky on Gastro-enterostomy in the Breslau Clinic; article by Charles L. Gibson, in "Annals of Surgery," Aug., 1898). In order to lessen the danger of vomiting after gastro-enterostomy, use a local anesthetic whenever possible (Fowler).

After Billroth's operation (Fig. 494), and in all the earlier methods, the contents of the duodenum certainly pass into the stomach, mix with the stomach-contents, and usually, but not always, pass into the efferent loop. In

all these operations there is great danger of the development of a vicious circle.

Lücke devised an operation with the idea of preventing such a complication. In the Lücke operation the direction of peristalsis in the efferent loop is the same as in the stomach (Fig. 492). McGraw points out that the crossing of the loop which is effected is dangerous. The Wölfler-Lücke

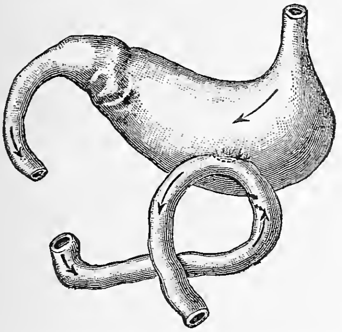


Fig. 492.—Gastro-enterostomy (after Lücke).

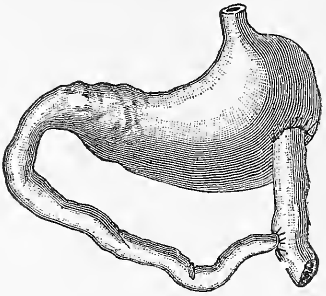


Fig. 493.—Implantation of duodenum into jejunum and jejunum into stomach (after Wölfler).

operation is shown in Fig. 502. Wölfler devised the operation pictured in Fig. 493. Von Hacker's posterior operation is thought by some to be less apt than the anterior method to be followed by the vicious circle (Fig. 503). Kocher devised an operation in which a valve is formed, but, as Fowler points out, this valve does not prevent filling of the duodenum and imbibition of the material by the stomach; and, further, that the valve does not work when the parts become cicatricial (Fig. 496).

The combination of gastro-enterostomy with entero-anastomosis does tend to prevent the vicious circle. This operation is shown in Figs. 500 and 501. The defect in such an operation is that there is still a communication between the stomach and the efferent loop. Fowler's operation (Fig. 504) corrects this defect. McGraw's operation (Figs. 497 and 498) tends to prevent the formation of a vicious circle. It seems certain that the danger of the formation of a vicious circle is greatest after a long-loop anterior operation and least after a short-loop posterior operation. The shorter the loop, the less the danger, hence the latter is the operation of choice. The safest operation of all is the short loop operation of Moynihan or Scudder (page 938), or the "no-loop" operation of the Mayos (page 940).

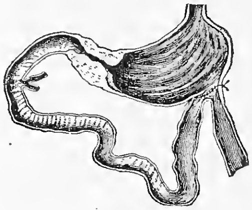


Fig. 494.—Billroth's method of gastro-enterostomy.

Treatment of Persistent Vomiting after Gastro-enterostomy.—If vomiting persists in spite of gastric lavage and rectal feeding after the operation of gastro-enterostomy without entero-anastomosis, open the abdomen again and perform anastomosis between the afferent and efferent loops of intestine.

Anterior Gastro-enterostomy.—*Senn's Method.*—A median incision is made through the abdominal wall, from below the xiphoid cartilage to the

umbilicus. An opening is made in the lower part of the anterior wall of the stomach in the direction of the long axis of the viscus, and its edges are stitched with a continuous catgut suture. The contents of the jejunum are forced along to below the point where an incision is to be made. The duodenal loop of jejunum should be from 12 to 14 inches in length. A rubber tube is fastened around the bowel above this point, and another below it; an incision is made in the long axis of the bowel, and the margins of the wound are sutured in the same manner as the stomach-wound. Bone plates are introduced into the stomach and intestine, and the ligatures are tied as in intestinal anastomosis. Catgut rings or rubber rings may be used.

Mayo's Anterior Method (Fig. 495).—Open the abdomen, and pick up the small intestine and find a point of jejunum about 14 inches from the point at which it emerges from under the mesocolon. Effect the union to the inferior border of the stomach close to the greater curvature and at the lowest portion of the stomach pouch. When the anastomosis is completed, the stomach pouch is funnel-shaped. The usual custom has been to place the opening higher on the anterior wall. It sometimes led to the formation of a pouch on the anterior wall, did not drain the stomach, and caused vomiting. After the performance of gastro-enterostomy the edges of the omentum are caught upon each side of the anastomosis and are sutured to each other and to the stomach-wall one inch above the opening. The edges are then united to each other in a downward direction for about three inches so as to form an apron over the anastomosis, yet not connected with it. Catgut is used for suturing. If leakage occurs, the omentum is adjacent and "available." If leakage does not occur, the omentum soon returns to its normal position (Wm. J. Mayo, in "Annals of Surgery," Aug., 1902).

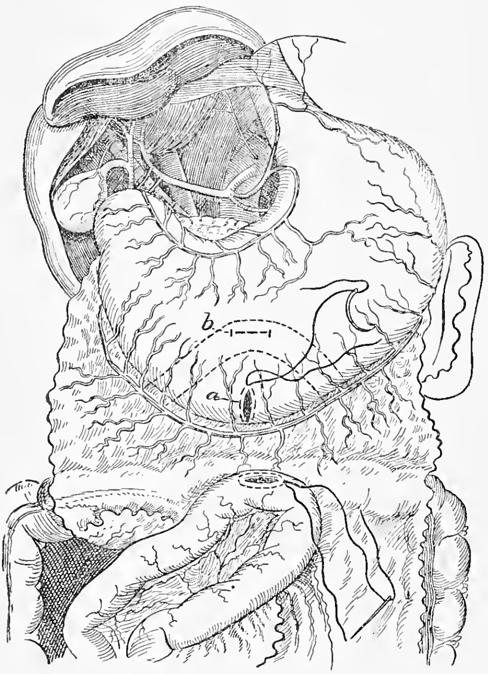


Fig. 495.—Mayo's method of gastro-enterostomy, showing proper and improper locations of openings: *a*, Proper position, leaving no pouch; *b*, usual position, forming intragastric pouch ("Annals of Surgery").

Kocher's Method (Fig. 496).—After opening the abdomen, lift up the omentum, pull up a loop of intestine, and find the point where the jejunum appears from under the mesocolon. Select a loop sixteen inches from the origin of the jejunum and prepare to attach it to the stomach. Wölfler

believed that the intestine should be applied to the stomach in such a manner that the direction of peristalsis in the bowel must correspond to the direction of the stomach-tide. This can be accomplished by having the proximal portion of gut to the left, and the distal portion to the right. The operation is to be so performed that after its completion the stomach-contents pass into the distal portion of the gut, and the intestinal contents do not tend to enter the stomach. In order to accomplish this Kocher hangs the intestine to the stomach-wall in such a manner that the proximal portion of the loop is posterior and ascending, and the distal portion is anterior and descending. The bowel is hung to the stomach by a continuous serous suture of silk, the ends of which are left long. The intestine is opened by a curved incision, the convexity of which is downward. The stomach is opened so that the convexity of the cut is upward. The valve-like portion of the bowel-wall is sutured to the stomach below the incision in that viscus. The two openings are well approximated by sutures.

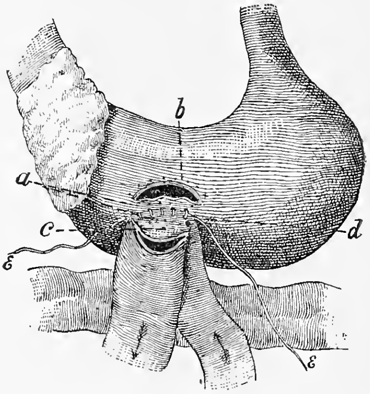


Fig. 496.—Kocher's method of gastro-enterostomy: *a*, Places of posterior annular suture through entire wall of stomach and intestine; *b*, places of anterior annular suture through the entire wall; *c*, valve at the jejunum by arch-formed incision; *d*, posterior annular suture of the serosa; *e*, thread ends for continuing anterior suture of the serosa.

Operation by McGraw's Elastic Ligature (Figs. 497–499).—The elastic ligature was introduced by Silvestri in 1862 and was first used in intestinal anastomosis by the same surgeon. McGraw perfected the operation in 1891 (see Dudley Tait, in "Annals of Surgery," Feb., 1906). The operation may be anterior or posterior. The intestine and stomach are sutured together by Lembert stitches. The elastic cord, which is 3 to 5 mm. in diameter, is passed through the stomach and then the bowel, in the long axis of each, and is tightly tied, and the knot is fastened with a silk thread. Another row of Lembert sutures buries the elastic cord from sight. The cord cuts through in from forty-eight to seventy-two hours and makes the anastomosis. Thus the danger of infection is greatly lessened, for when the anastomosis opening is formed, it is completely encompassed by firm adhesions. Further, the danger of the formation of a vicious circle is greatly lessened, because there is no communication between the stomach and bowel for between forty-eight and seventy-two hours, the period in which vomiting of the type previously described is most apt to occur. The method is not suitable for absolute pyloric occlusion. In this condition it is imperative to give nourishment early, and, again, an ordinary gastro-enterostomy allays autointoxication and this operation cannot until the ligature cuts through. It is particularly valuable in the performance of lateral intestinal anastomosis.

Jaboulay's Gastro-duodenostomy.—This operation was devised by Jaboulay in 1892. It aims to obviate some of the objections to pyloroplasty and at the same time to retain the advantages this operation possesses over

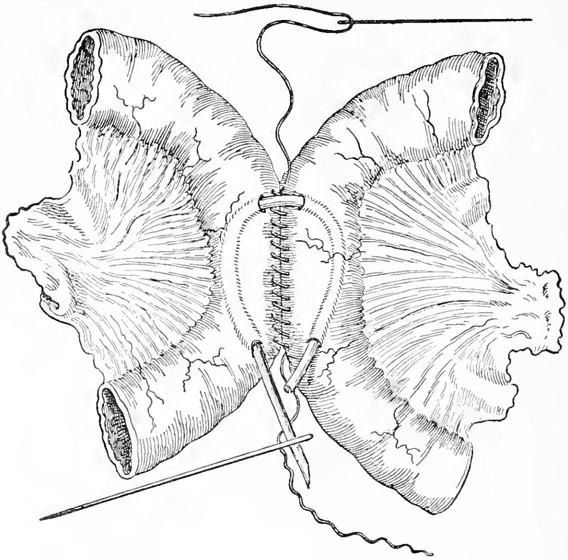


Fig. 497.—McGraw's method of lateral anastomosis. The elastic ligature is introduced (Walker).

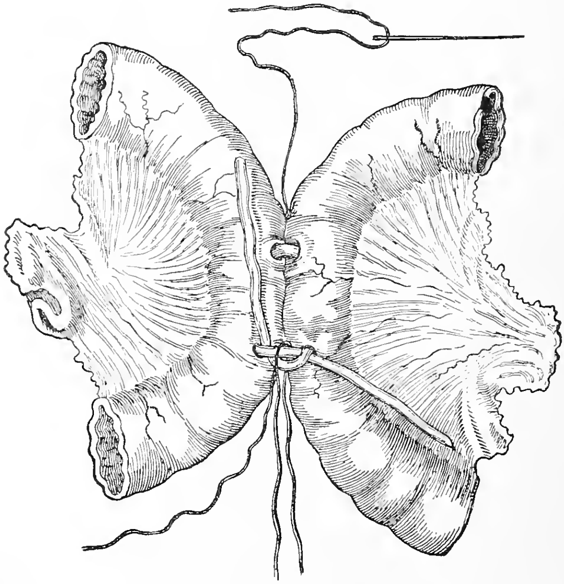


Fig. 498.—McGraw's method of lateral anastomosis. One tie of the elastic ligature with a strong silk ligature underneath ready to fasten the elastic ligature where it is drawn taut (Walker).

gastro-jejunostomy. Jaboulay's gastro-duodenostomy has never become popular with surgeons, and Finney's method is much more satisfactory (page 921).

Posterior Gastro-enterostomy (Fig. 503).—In a thin subject with a long mesocolon posterior gastro-enterostomy is to be chosen, but if the mesentery is

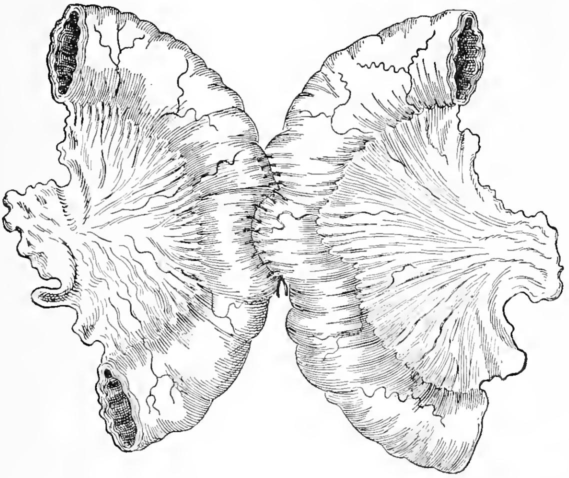


Fig. 499.—McGraw's method of lateral anastomosis. The operation completed (Walker).

short or contains much fat, or if the vascular loop coming from the superior mesenteric artery, and which supplies the transverse colon with blood, is small, so that on opening the posterior layer of the gastro-colic omentum it would be close to the artery, the anterior operation is employed (Wm. J. Mayo, in "Annals of Surgery," Aug., 1902). If a Murphy button is used, the posterior operation

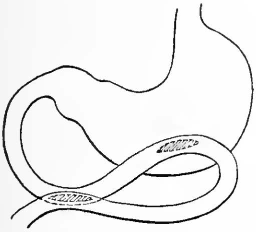


Fig. 500.—Jaboulay's method of gastro-enterostomy.

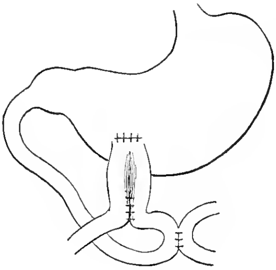


Fig. 501.—Braun's method of gastro-enterostomy.

is selected. The operation is commonly performed as follows: After the abdomen has been opened, the stomach and omentum are raised; a portion of the upper jejunum is seized, emptied, and tied with tubes as previously described. The portion selected should be at least ten inches below the emergence of the jejunum from under the mesocolon. A spot is selected on the transverse

mesocolon where there are no vessels, and an opening is made through the mesocolon with a dry dissector. The posterior wall of the stomach is pulled into the opening and sutured to its edges. This prevents downward displacement of the stomach and obstruction of the loop of gut. The sutures are so inserted that a flap is formed of the mesenteric margin to protect the line of junction of the anastomotic opening (Willy Meyer). An anastomosis is then performed. Regurgitation is less common after posterior than after anterior gastro-enterostomy. In 250 posterior operations in Czerny's clinic there was not one case of regurgitant vomiting. One hundred and seventy cases were button operations and 45 were by sutures alone (Peterson). Von Hacker had one instance of regurgitation in 60 posterior operations.

Operation by the Murphy Button.—Gastro-enterostomy may be quickly performed by the use of a large-sized Murphy button. Murphy says that in some reported cases the button has slipped back into the stomach, but this accident can be prevented by the use of an oblong button and by making the anastomosis on the posterior stomach-wall. The same surgeon advises us to

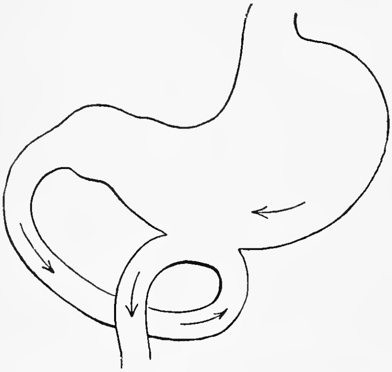


Fig. 502.—Wölfler-Lücke method of gastro-enterostomy.

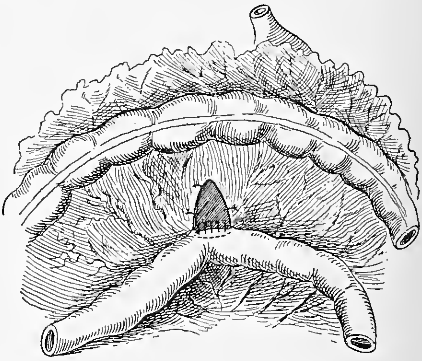


Fig. 503.—Von Hacker's posterior gastro-enterostomy.

scarify the peritoneum to hasten union, and says supporting sutures about the button are not required, except when considerable tension exists. There is no question that an anastomosis on the anterior wall, accomplished by a Murphy button, can be speedily performed. Anastomosis on the posterior wall cannot be performed so speedily, and it sacrifices to some extent the great advantage of the button operation—that is, speed. In spite of the reported cases we can positively assert that the danger of the button producing grave trouble is slight. In some cases it drops into the stomach and remains there, but seems to do no harm. In other cases it takes a long time to pass. In one of the author's cases it did not pass until the eighty-sixth day. If it does not pass in two or three weeks, the rectum should be explored with the finger from time to time to see if it is lodged there. The x-rays may determine whether the button is in transit. If the wall of the stomach is thick, the incision should be made in the stomach-wall before the suture is passed, and this suture should pick up only a small portion of the stomach-wall, otherwise the button may be retained in place for a very long time (Wm. J. Mayo). "In many cases in which the button passes, vomiting with symp-

toms of obstruction may appear in the second or third week while it is in transit. Gastric lavage and rectal feeding for a day or two cause these symptoms to subside" (Wm. J. Mayo, in "Annals of Surgery," Aug., 1902). Mayo considers the suture operation as good as the button, and thinks the results are about the same. Mikulicz says that in the suture operation entero-anastomosis is necessary, but not in the button operation, because the button, while in place, prevents angulation. The last-named surgeon uses the button in malignant cases and the suture in benign cases. Czerny is an advocate of the button. Every button should be tested before it is used. Mayo finds nearly 20 per cent. of buttons imperfect and dangerous.

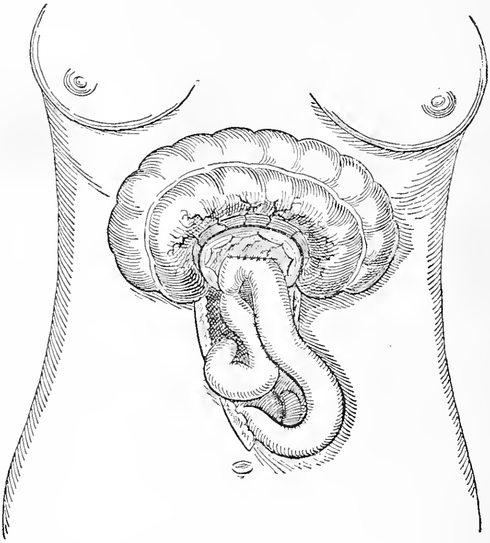


Fig. 504.—Fowler's method of gastro-enterostomy.

Fowler's Method (Fig. 504).—Anastomose the posterior wall of the stomach to the jejunum and do an entero-anastomosis between the afferent and efferent loops of jejunum. Pass a No. 20 silver wire two or three times around the afferent loop of jejunum and draw it sufficiently tight to occlude the lumen without strangulating the wall of the gut. The ends are twisted, cut short, rolled into a flat coil, the cut ends being in the coil. (See Geo. Ryerson Fowler on the "Circulus Vitiosus" following gastro-enterostomy, "Annals of Surgery," Nov., 1902.) This operation positively prevents the entrance of material from the duodenal loop into the stomach and also drains that loop.

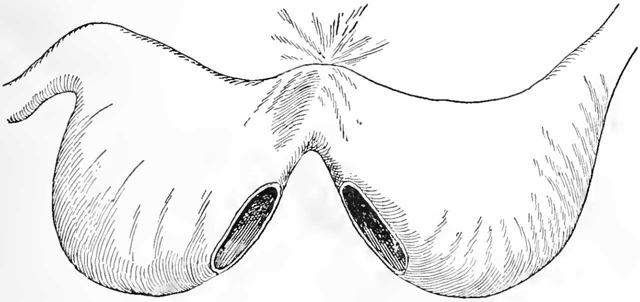


Fig. 505.—Wölfler's method of gastrogastrostomy for hour-glass stomach, showing the anastomotic openings.

Moynihan's Method.—This is the plan I usually employ. It is easy, rapid and clean. Make a 4-inch incision 1 inch to the right of the middle line and above the umbilicus. Open the anterior sheath of the rectus and separate it from the front of the muscle as far as the middle line. Draw the entire muscle outward, open the posterior portion of the sheath, and then open the belly. Inspect and feel the entire stomach. Lift the omentum and transverse colon out of the abdomen and make the mesocolon taut by raising the stomach and colon with the left hand. Find "a bloodless spot in the arch of the middle colic artery," pick up a bit of the under surface of the mesocolon with a pair of hemostatic forceps, lift it from the posterior stomach-wall, and open the lesser sac of peritoneum by the use of the scissors. Enlarge the opening by dilatation or tearing until it admits three fingers. Inspect and feel the posterior stomach-wall. Place the stomach in its natural position, mark with the thumb the lowest part of the stomach-wall posterior, and again turn the viscus over. From the spot marked by the thumb a fold is raised. The fold is oblique and its upper end is to approach the cardia and lesser curvature. A stomach clamp (Fig. 506) having a rubber tube bent over each blade is applied obliquely so as to grasp the base of this fold. In applying the clamp the tip should point to the right shoulder and the handle to the outer side of the left hip, and the lowest portion of the stomach is grasped in the tip of the blade of the clamp (Fig. 507). The clamp is now put in a horizontal position. The duodenojejunal flexure is found with the finger and a point on the jejunum 5 inches from it is determined, and this portion on the side of the gut opposite the mesentery is clamped. The clamped gut is placed by the side of the clamped stomach, a bit of gauze being put between them (Fig. 508). The stomach (except the clamped portion), the omentum, and transverse colon are returned to the abdomen and the clamps are surrounded with gauze. Each clamp holds a fold $3\frac{1}{2}$ to 4 inches in length. Pagenstecher's celluloid thread is used for suturing. The first line of sutures is passed as shown in Fig. 509. In front of these sutures an incision is made into the stomach and jejunum, the serous and muscular coats being first divided,

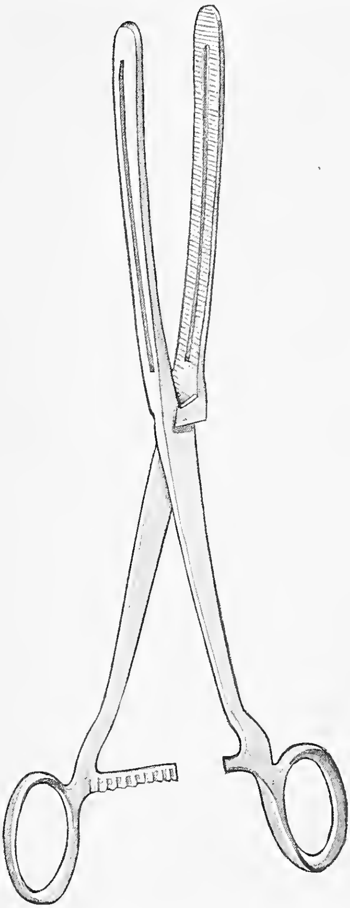


Fig. 506.—Moynihan's clamp for gastric and intestinal operations (made by Down Brothers, London).

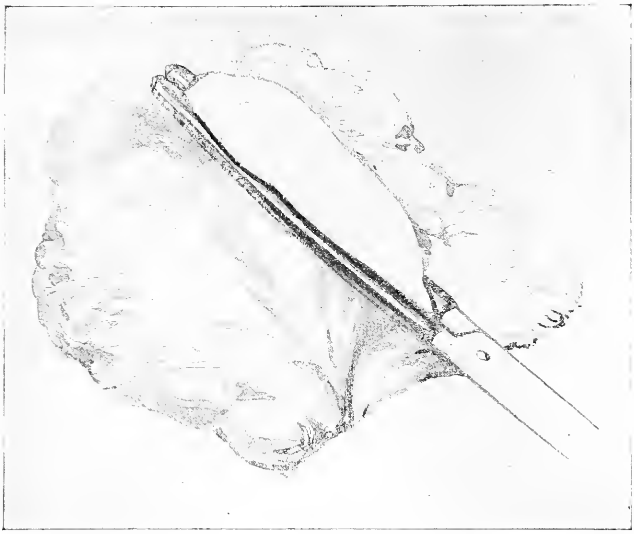


Fig. 507.—Moynihan's method of gastro-enterostomy. The oblique application of the clamp to the stomach (Moynihan).

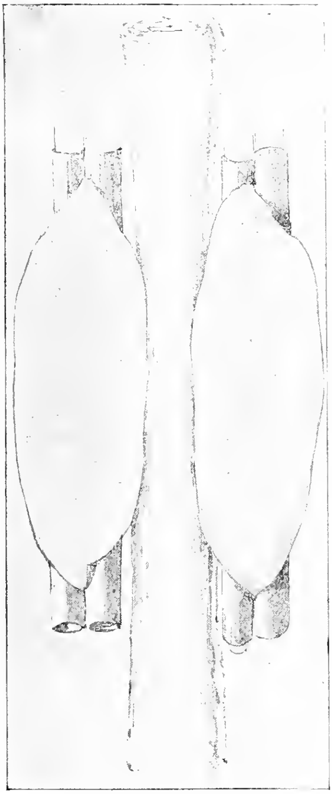


Fig. 508.—Moynihan's method of gastro-enterostomy. The strip of gauze between the clamps (Moynihan).

Fig. 509.—Moynihan's method of gastro-enterostomy. The first layer of serous suture (Moynihan).

and an ellipse of mucous membrane being removed (Fig. 510). The next row of sutures is inserted as shown in Fig. 511. When this row is completed the clamps are removed and the long suture of the first row is picked up again and the operation is completed (Fig. 512). Finally the edges of the mesocolic opening are sutured to the jejunum. The parts are cleansed with salt solution, the suture line is inspected, the parts are returned to the belly, and the abdomen is closed. (See Moynihan's "Abdominal Operations.")

The No-loop Operation of the Mayos (Figs. 513–515).—In this operation the gastric opening, which is placed in the line advised by Moyni-

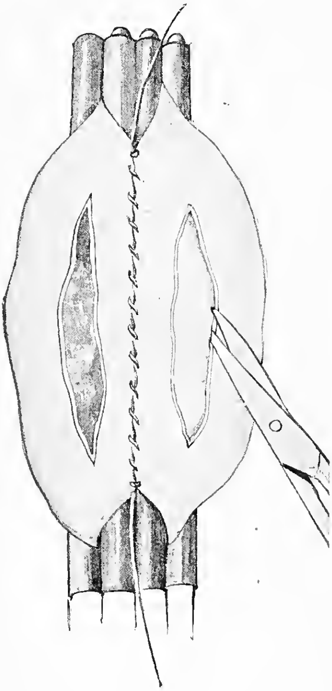


Fig. 510.—Moynihan's method of gastro-enterostomy. Removal of the ellipse of mucous membrane (Moynihan).

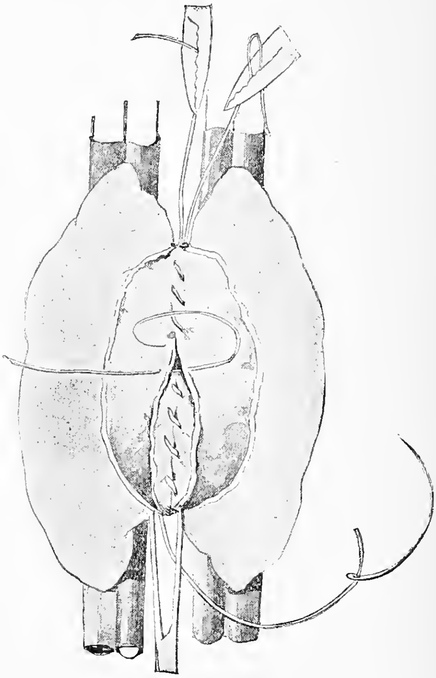


Fig. 511.—Moynihan's method of gastro-enterostomy. The inner suture, continued (Moynihan).

han, extends one-fourth or one-half inch into the anterior wall of the stomach, and thus the lowest part of the opening will be the lowest part of the stomach (Fig. 513). The incision in the intestine begins from 1 to 3 inches from the origin of the jejunum, the measure being made on the anterior surface (Fig. 513).

The object is to get as short a piece of jejunum as can be attached without tension. The operation is described as follows (Wm. J. Mayo in "Annals of Surgery," Nov., 1905).

"(*a*) The abdominal incision is made 4 inches in length, $\frac{3}{4}$ inch to the right of the middle line, the fibers of the rectus muscle being separated. The lower end of the external wound lies opposite the umbilicus. This opening

also enables inspection of the duodenum and gall-bladder and is reliable against hernia when closed.

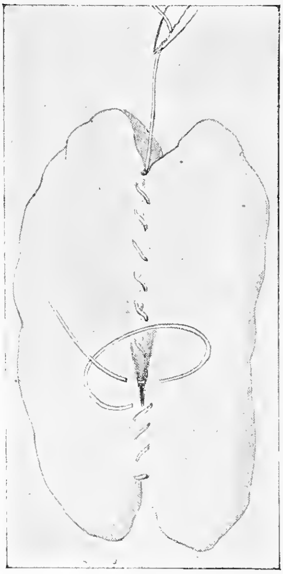


Fig. 512.—Moynihan's method of gastro-enterostomy. The serous suture resumed (Moynihan).

"(*b*) The transverse colon is pulled out and the mesocolon made taut by traction upward and to the right, in this manner bringing the jejunum into view at its origin.

"(*c*) About 3 to 4 inches of the jejunum opposite the mesentery are drawn into a slightly curved clamp. The handles of the clamps should be to the right, to enable a short grasp on the intestine. Three-fourths of the circumference of the bowel is pulled through; the posterior border is not included, to prevent entanglement of the suture with the redundant posterior mucous membrane. The holding clamps are applied sufficiently tight to check hemorrhage and prevent extravasation of intestinal contents.

"(*d*) The ligament of Treitz is a short muscular mesentery covered by a variable peritoneal fold (too variable for a reliable landmark) extending upward from the origin of the jejunum on to the mesocolon. This peritoneal fold lies at the base of the arterial loop of the middle colic artery which supplies the transverse colon. The mesocolon is opened within the vascular loop and the posterior inferior border of the stomach pushed through. A small separation of the greater omental attachment to the stomach enables the anterior gas-

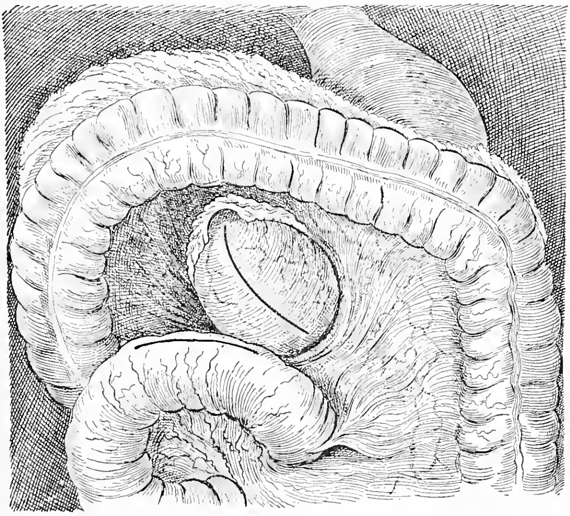


Fig. 513.—Mayo's method of gastro-enterostomy. Showing posterior wall of the stomach drawn through a rent in the transverse mesocolon. Note slight separation of gastrocolic omentum from its attachment to the stomach, permitting anterior wall of stomach to appear, and insuring drainage at lowermost level. Black lines mark site of proposed anastomosis; the jejunum shows at its origin.

tric wall to be drawn out posteriorly. The posterior gastric wall is drawn into a clamp, with the handles to the right, in such a manner as to just expose the anterior wall at the base.

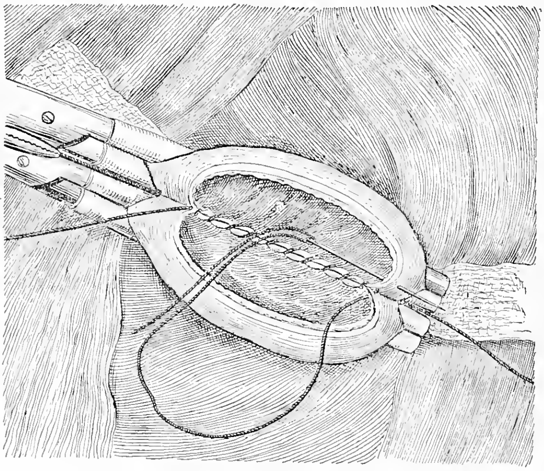


Fig. 514.—Mayo's method of gastro-enterostomy. Forceps in place and anastomosis half completed by suture.

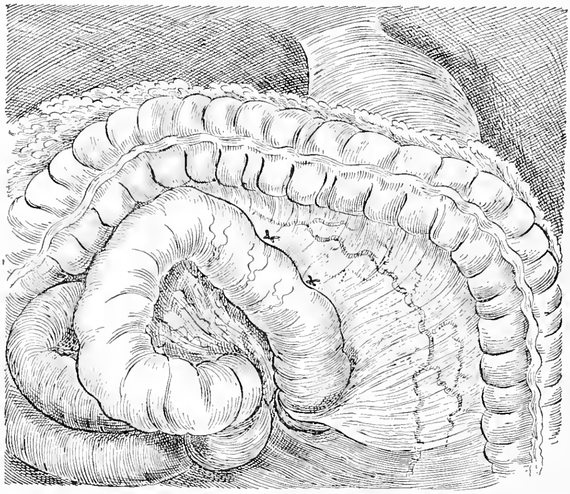


Fig. 515.—Mayo's method of gastro-enterostomy. Completed operation from behind margin of torn mesocolon attached by several interrupted sutures to line of union.

"(*e*) The two clamps are laid side by side and the field carefully protected by moist gauze pads. With fine celluloidal linen thread on a straight needle the intestine is sutured to the stomach from left to right by a Cushing suture at least 2½ inches.

"(*f*) The stomach and intestine are incised $\frac{1}{6}$ inch in front of the suture line and the redundant mucous membrane excised flush with the retracted peritoneal and muscular coats. With a No. 1 chromic catgut on a straight needle the posterior cut margins of the entire thickness of the gastric and jejunal wall are united by a button-hole suture from right to left; at the extreme left the suture changes to one which passes through all the coats, of each side alternately, from the peritoneal to the mucous, then directly back on the same side from the mucous to the peritoneal. This acts as a hemostatic suture, and also turns the peritoneal coats into apposition. It passes around the anterior surface and is tied to the original end, which has been left long for the purpose. If silk or linen is used for this suture, it may hang *in situ*, suppurating for months.

"(*g*) The clamps are now removed and the linen thread continued around until it is tied to the original end, firmly catching the blood-vessels in sight along the suture line. The parts are carefully cleansed and inspected. If

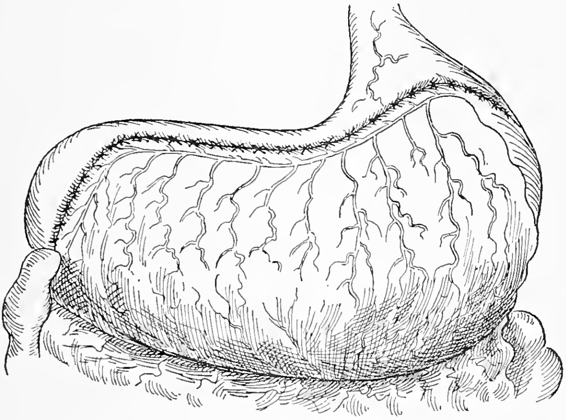


Fig. 516.—Bircher's method of gastroplication.

necessary, a suture or two is applied to accurately coapt or to check the oozing.

"(*h*) The margins of the incised mesocolon are now united to the suture line by 3 or 4 interrupted sutures, and the parts returned into the abdomen."

Gastrogastrostomy is an operation performed for hour-glass contraction of the stomach, a condition which occasionally ensues on the healing of an ulcer. In this operation an anastomosis is effected between the pyloric and cardiac ends (Fig. 505). Wolfe, Watson, Wölfler, and Eiselberg have performed this operation. Weir and Foote maintain that double gastro-enterostomy, "tapping each sac," is a preferable procedure.* In some cases an operation identical with pyloroplasty can be performed (incision of the constriction in the direction of the long axis of the stomach and suturing vertically—*gastroplasty*). Watson folds the two stomachs over each other, using the narrow isthmus as a hinge; sutures the pouches together and leaves

*F. S. Watson, in Boston Med. and Surg. Jour., April 2, 1896; Weir and Foote, Medical News, April 25, 1896.

the ends of the sutures long. He incises the anterior wall of the anterior stomach in order to obtain access to the double septum between the two pouches. He makes an anastomosis opening through the double septum, sutures the edges, and closes the wound in the anterior wall of the anterior stomach.

Gastroplication (Brandt's Operation of Stomach=reefing for Dilated Stomach).—Apply sutures in the anterior wall so as to form reefs, then tear through the great omentum and apply sutures in the posterior wall. The sutures pass through the serous and muscular coats. A continuous suture may be used on the anterior wall and another on the posterior wall, or numerous interrupted sutures may be inserted. This operation is of questionable value, and must never be used if stenosis of the pylorus exists, and stenosis of the pylorus is the most common cause of gastric dilatation.

Bircher's method of gastroplication is shown in Fig. 516.

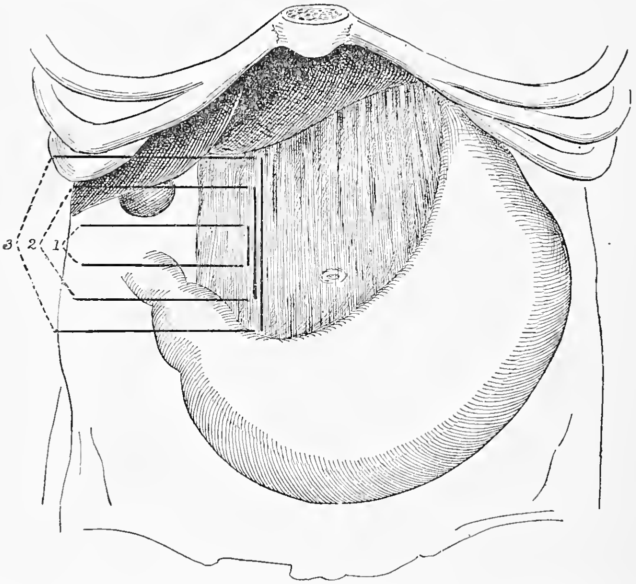


Fig. 517.—Beyea's operation for gastroptosis: 1, Position of one suture of first row; 2, one suture of second row; 3, one suture of third row. Others of each row introduced at intervals to and including the gastrophrenic ligament.

Gastropexy (Duret's Operation for Gastroptosis).—It has been shown by Duret that dyspepsia of a peculiarly severe type may be produced by prolapse or downward displacement of the stomach. In this condition he advised the following operation: Perform a median laparotomy, but do not incise the peritoneum in the upper portion of the wound. Expose the stomach and fix it by means of a silk suture to the undivided but exposed peritoneum. The suture should be parallel to the lesser curvature and near the pylorus should be horizontal.* Duret's operation, the operation of Rovsing, and the operation of Hartman, fix and distort the stomach. Beyea has devised an operation which is free from this objection.

*Rev. de Chir., June, 1896.

Beyea's Operation for Gastroptosis.—Insert three rows of interrupted silk sutures through the gastrohepatic omentum and the gastrophrenic ligament. Each suture is passed from above downward and the row begins at the right and passes to the left (Fig. 517). When the sutures are tied, a fold or plication is formed in the ligaments, the supports of the stomach are shortened, and the viscus is elevated to a normal position without any disturbance of its physiological mobility ("Univ. of Penna. Med. Bull.," Feb., 1903).

Duodenostomy and Jejunostomy.—It has been suggested that one of the above operations should be performed in a case of pyloric obstruction in which pylorectomy is not feasible. Duodenostomy is an easy operation because of the mobility of the pylorus and first part of the duodenum, and it is not only easier, but is safer, than jejunostomy, because it makes the fistula above the opening of the common bile-duct ("Bull. et Mém. de la Soc. de Chir. de Paris," No. 39, 1901). Cackove advocates the operation in some cases of gastric ulcer with repeated hemorrhages and some cases of gastric cancer. In the latter cases he asserts that the mortality is about the same as from gastro-enterostomy and the prolongation of life is greater ("Arch. f. klin. Chir.," Bd. lxv, Heft 2). Hartman's case of duodenostomy lived two months. The operation was performed for extreme cicatricial stenosis of the pylorus due to swallowing hydrochloric acid. Moynihan points out that if the operation is done at all, the indication for jejunostomy is cancer involving the entire stomach or leather-bottle stomach. He operated on 2 cases. One lived one month and one seven weeks (B. G. A. Moynihan, "Brit. Med. Jour.," June 28, 1902).

Jacobson disapproves of both procedures, and objects particularly to duodenostomy, because it involves a portion of the intestine which is difficult to deal with, and because important fluids escape constantly from the fistula.*

The same author objects to jejunostomy because of the inevitable leakage of nutritive fluids.

Reported cases of duodenostomy and jejunostomy certainly do not indicate that the operations prolong life to any considerable degree.

Enterectomy, or Resection of the Intestine with Approximation by Circular Enterorrhaphy.—How much of the intestine can be removed without the patient dying from lack of nutrition? The question is not settled. It has been stated that the removal from an adult of more than six and two-thirds feet produces intestinal disturbance, and that a child tolerates the removal of a piece relatively larger better than does an adult. Certain it is that great lengths have been successfully removed, and the patients have not only lived, but have been well nourished. Ruggi removed eleven feet successfully. Hayes removed eight feet four and one-half inches from a boy of ten years of age, and the patient was well eight months later. Dressman reported 26 cases in each of which more than three feet three inches had been removed (Alexander Blaney, in "Brit. Med. Jour.," Nov. 16, 1901). Blaney adds 7 cases from literature, and tells us that in 9 of the 33 cases death occurred soon after operation.

Alexander Blaney, in the previously quoted article, reviews the subject of the resection of great lengths of intestine. He tells us that how much remains after a resection is important but uncertain. It is uncertain because, as

*Jacobson's "Operations of Surgery."

Treves has shown, the length of the intestine varies from fifteen feet six inches to thirty-one feet ten inches.

Resection of the jejunum is much more dangerous than resection of an equal length of ileum. If resection is employed, all diseased or injured bowel must be removed irrespective of ultimate bad consequences (Blaney). The operation is performed as follows: After opening the abdomen isolate the loop of intestine we intend to resect. Push a rubber tube through the mesentery close to the bowel, above the seat of operation, and pass a rubber tube through the mesentery below the seat of operation. Empty this segment of bowel by squeezing and stroking, tighten the rubber tubes, and clamp them to keep the bowel empty (Fig. 518). Instead of tubes, strips of iodoform gauze may be used to encircle the bowel. The diseased intestine is resected, each incision being carried through a healthy segment, and care being taken that the cuts are so arranged that at each end a blood-vessel from the mesentery reaches the edge of the cut bowel. Otherwise repair can scarcely occur. The lumen of each end of the divided gut is irrigated with salt solution. The divided surfaces are approximated by a double row of sutures—a

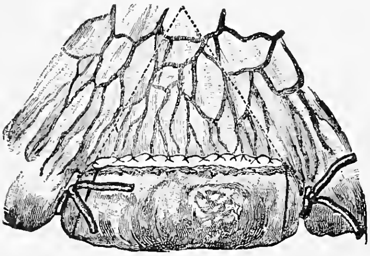


Fig. 518.—Excision of bowel; first step (Esmarch and Kowalzig).

Fig. 519.—Excision of bowel with enterorrhaphy and stitching of the redundant mesentery; second step (Esmarch and Kowalzig).

continuous suture for the mucous membrane, and Lembert's, Dupuytren's, or Cushing's suture to effect inversion. Thoroughly satisfactory approximation can be effected by one row of Halsted sutures. If a redundant fold of mesentery is left, it can be stitched at its raw edge (Fig. 519). Many surgeons remove a V-shaped piece of mesentery and tie the divided mesenteric vessels (Fig. 518). The tubes are removed, and the wound is cleansed, closed, and dressed.

Senn effects invagination by means of a bone ring (Fig. 521).

If the two segments of bowel are unequal in size, the narrow part of the bowel should be cut obliquely and the larger part should be cut transversely. To meet this complication Billroth devised *lateral implantation* (Fig. 550). Suppose the cecum has been resected; its lower end is closed by Lembert sutures, an opening is made in the long axis of the periphery of the colon opposite the attachment of the mesocolon, and the end of the ileum is sutured into this incision. This is called *end-to-side approximation*, or implantation. It is used in the sigmoid, in the cecum, and in any intestinal segment in which the circulation is deficient. Eugene A. Smith ("Amer. Med.," May 10, 1902)

sums up the advantages of end-to-side approximation as follows: The strain of peristalsis is less than in end-to-end union; the circulation of each end of the bowel and the parts of bowel adjacent is better; each cut edge of mesentery is free to recover its circulation, and there is no dead space at the mesenteric border to lead to leakage.

Senn advises the insertion of an anastomosis-ring in the ileum, the invagination of the colon as the ring is pulled into place, and firm suturing of the

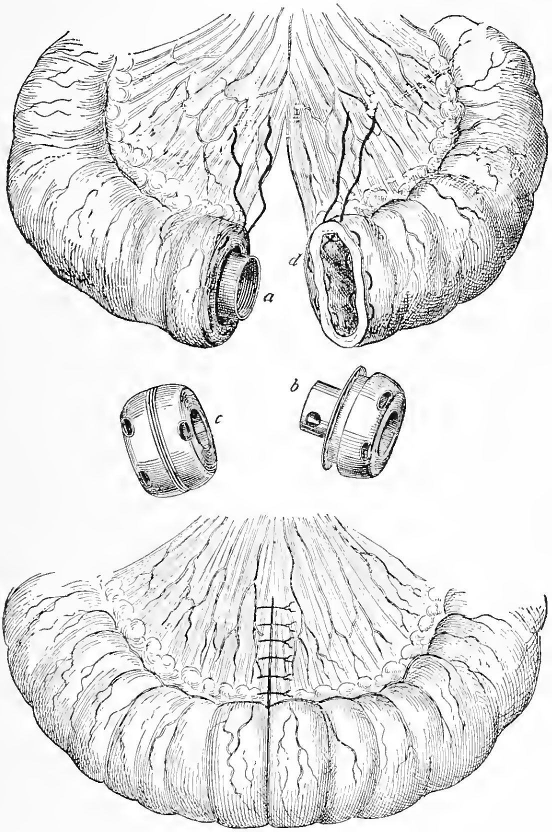


Fig. 520.—Resection of intestine: *a*, *b*, The two halves of the button; *c*, the two portions clamped together; *d*, introduction of the sutures for holding each half of the button in place. The lower figure shows the completed union of the intestine by the Murphy button; the slit in the mesentery has been closed by linear union (after Zuckerkandl).

line of junction. By Senn's method the ileum may be implanted into the end of the colon or into a slit in the wall of the large bowel after the end of the colon has been closed. In some cases, where one portion of bowel is larger than the other, lateral anastomosis is the preferable method. For a full week after an intestinal resection the patient is fed chiefly by nutrient enemata. During the first twenty-four hours nothing is given by the stomach but small amounts of hot water, and for the next six days but a little liquid food is allowed to be swallowed.

The use of *Murphy's button* permits of rapid approximation after resection (Fig. 520, *b* and *c*). This button closely approximates the portions of the intestine within its bite, rapid adhesion taking place. The diaphragm of tissue undergoes pressure-atrophy and liberates the button, which is passed per anum. It is claimed that the button-opening contracts but slightly. For end-to-end or side-to-side approximation of the small intestine a No. 3 button is used. For similar operations on the large intestine a No. 4 button is employed (Murphy). After the resection one half of a button is inserted into each segment, and is held in place by a purse-string suture of silk which passes through all the coats (Fig. 520). The redundant mucous membrane is tucked in or clipped off, so that it will not be interposed between the serous surfaces. The serous surfaces are scratched with a needle and the halves of the button are locked (Fig. 520). It is not necessary to surround the margin of junction with sutures. Murphy says that liquid nourishment should be given as soon as the patient has recovered from the effect of the ether, and that the bowels should be moved at an early period, and frequent evacuations should be maintained. If the button does not pass in four weeks, examine the rectum for it.* The situation of the button can be ascertained by the *x*-rays. An objection to the button is that it introduces a foreign body which must pass per rectum to complete the operation successfully. It may not pass, but

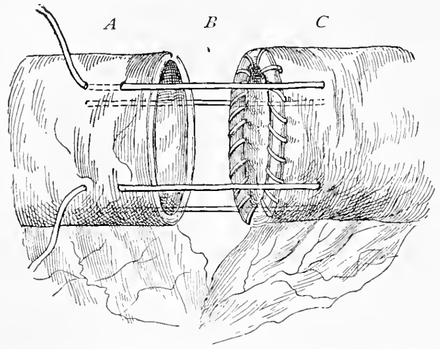


Fig. 521.—Senn's modification of Jobert's invagination method: *A*, Upper end lined with ring; *B*, invagination sutures in place; *C*, lower end.

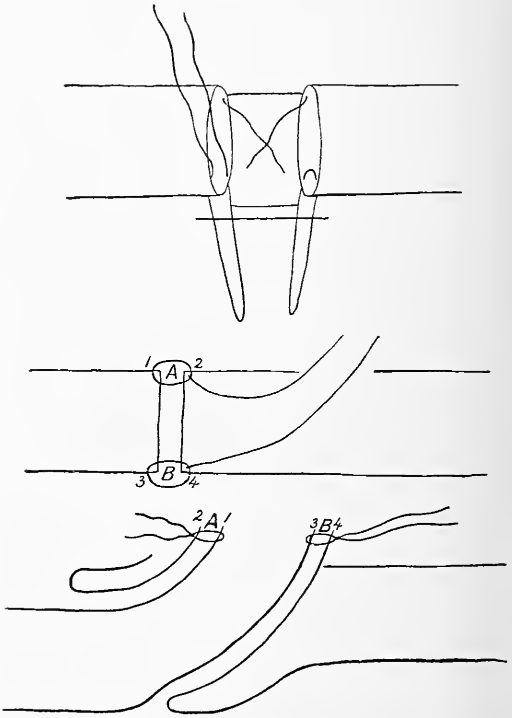


Fig. 522.—Maunsell's method of anastomosis (after Wiggin).

* John B. Murphy, in Med. News, Feb. 9, 1895.

trouble does not of necessity follow. But in some cases its retention leads to trouble, and obstruction ensues. If the caliber of the button blocks before dislodgment, obstruction follows; hence the rule to give saline purgatives the day after the operation.

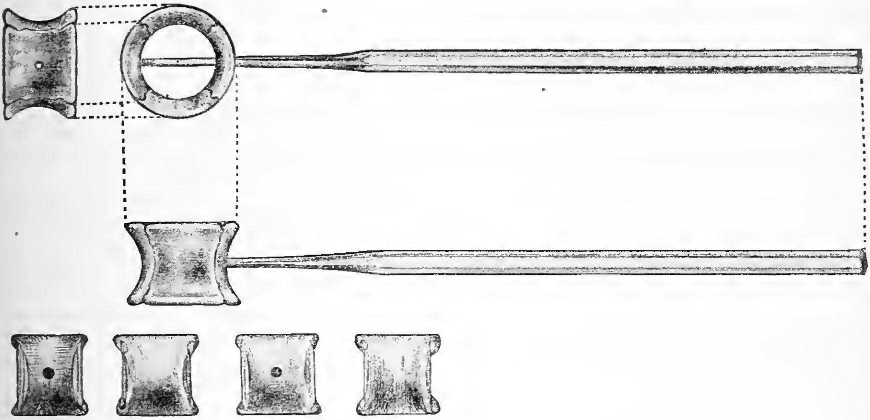


Fig. 523.—The segmented ring of Harrington and Gould.

Some surgeons have sought to make a button which would come apart and be absorbed after it had accomplished its purpose. The best of these appliances is Frank's coupler, which is made of bone, the compression being furnished by rubber. In this apparatus, however, the amount of pressure obtained is always uncertain and the rubber is apt to wear out. The button gives a lower mortality than the suture operation, and many surgeons now use it who once condemned it. Czerny is a strong advocate of the button.

After intestinal resection Halsted performs circular enterorrhaphy by means of mattress sutures (Figs. 529 and 530).

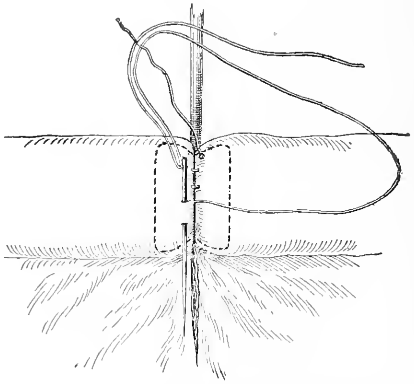


Fig. 524.—End-to-end union with aid of segmented ring. Continuous stitch beginning at one side of the handle (Harrington and Gould).

Harrington and Gould use a *segmented aluminum ring*. This ring collapses into small segments after the anastomosis has been effected. By its use the authors believe that the operation is made more rapidly and safely ("Annals of Surgery," Nov., 1904). During the suturing the ring is held by means of a handle, which, after the anastomosis has been effected, is removed. The ring in the handle is shown in Fig. 523 and the operation in Figs. 524, 525.

Maunsell has devised a most ingenious method of circular enterorrhaphy. The two portions of bowel are attached by two fixation sutures which penetrate all the coats (Fig. 522). An incision one and one-half inches in length is made

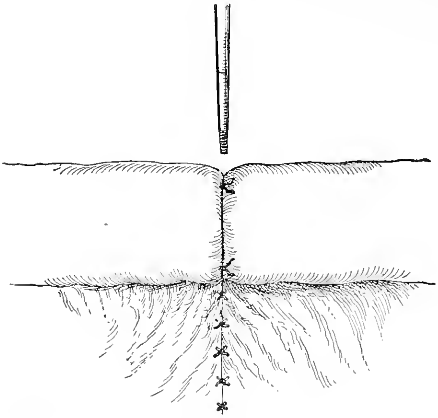


Fig. 525.—End-to-end union with aid of segmented ring. Handle unscrewed, suture completed (Harrington and Gould).

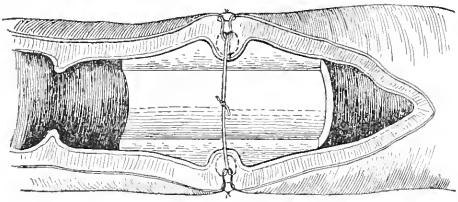


Fig. 526.—Robson's decalcified bone bobbin.

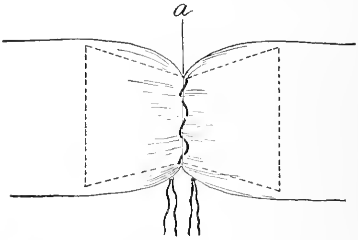


Fig. 527.—Allingham's decalcified bone bobbin.

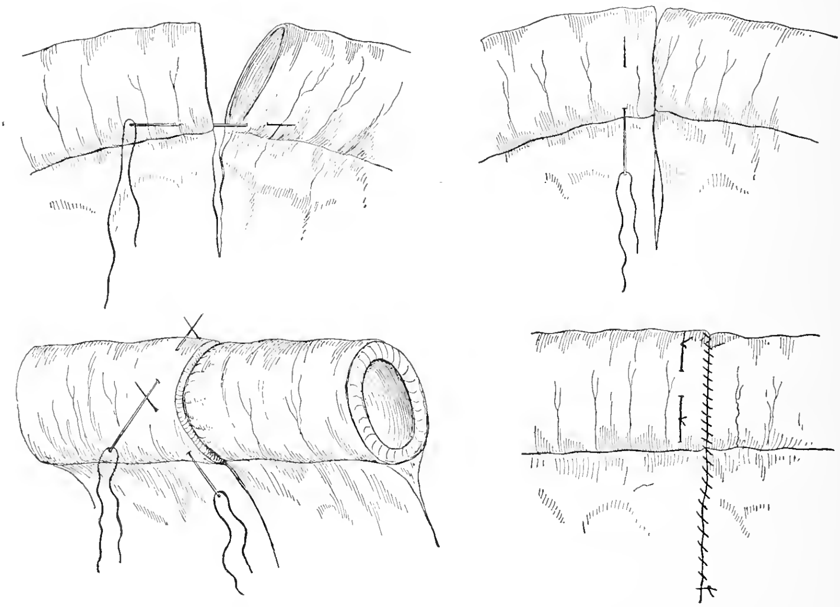


Fig. 528.—Harris's method of circular enterorrhaphy.

through the wall of the proximal segment of gut, about one inch from its edge. The fixation sutures are brought through this opening, traction is made upon them, the distal portion of the bowel is invaginated into the proximal portion, and the ends emerge from the opening, their peritoneal surface being in contact (Fig. 522). Sutures of silk are passed through both sides of the area of invagination, the threads are caught up in the center, cut, and tied on each side. The fixation sutures are cut off. The invagination is reduced by traction. The longitudinal cut is closed by Lembert sutures.

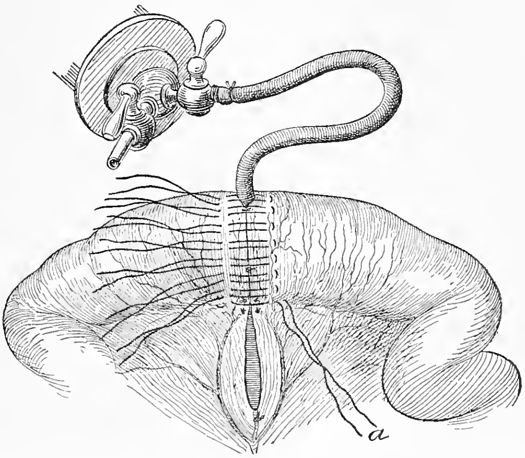


Fig. 529.—Use of Halsted's inflated rubber cylinder in circular enterorrhaphy.

A. W. Mayo Robson performs circular enterorrhaphy and brings the ends of the gut together over a bobbin of decalcified bone (Fig. 526). Allingham uses a bone bobbin the shape of two cones joined at their apices. The bobbin is decalcified, except an area at the center (Fig. 527). Kocher performs circular enterorrhaphy as follows: A fixation suture is introduced through the bowel at the mesenteric attachment and another is inserted at an opposite point. The intestinal ends are approximated by a continuous silk suture, which passes through all of the coats, but which includes more of the serous than of the mucous coat. The suture-line is overlaid by a continuous Lembert suture which includes the serous and a portion of the muscular coat. Harris removes a portion of mucous membrane from the distal end by means of a curet. Three needles are threaded with fine silk. The first needle is pushed through the bowel-wall to one side of the mesentery. The point of the needle

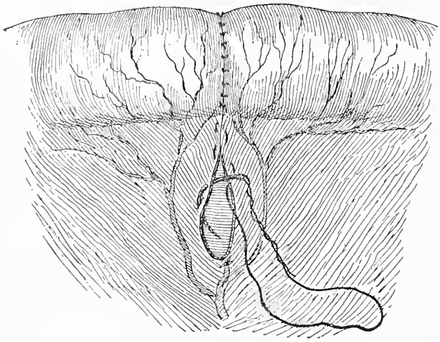


Fig. 530.—Suture of the mesentery after circular enterorrhaphy (Halsted).

Fig. 531.—Moynihan's method of end-to-end anastomosis (Moynihan).

Fig. 532.—Moynihan's method of end-to-end anastomosis continued.

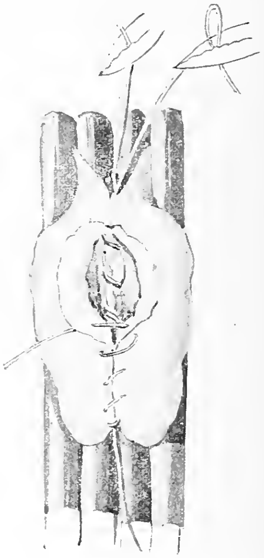


Fig. 533.—Moynihan's method of end-to-end anastomosis continued.

picks up a portion of the distal end transversely. The needle is used as a lever to invaginate the distal end into the proximal end. The same procedure is carried out with the other needles. When invagination is effected the needles are pulled through and the threads are tied. The free end of the bowel is now sutured to the invaginated part by interrupted inversion sutures or by a continuous inversion suture broken once (Fig. 528).*

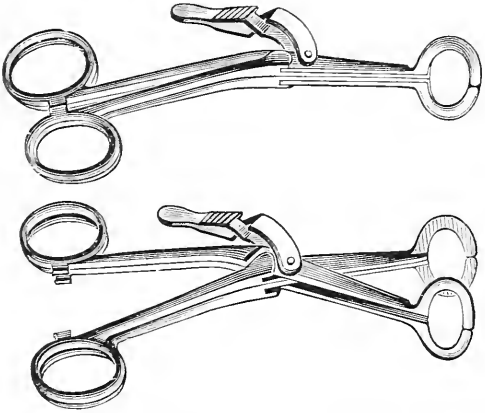


Fig. 534.—Laplace's forceps for intestinal anastomosis.

In doing an end-to-end approximation I prefer to use the clamps of Moynihan as shown in Figs. 531, 532, and 533. We thus are able to hold the parts and keep them clean, rapidly make an even and secure stitch line, and have no free-edged septum.

* Chicago Med. Recorder, Jan., 1897.

Some surgeons employ inflatable rubber cylinders in making an end-to-end anastomosis (Halsted, Downes, and others). The method was devised by Treves, but was subsequently abandoned by him. *Halsted* maintains that the use of the inflatable rubber cylinder enables the surgeon to finish the operation more quickly and to dispense with clamps; arrests the vermicular motion of the intestine; makes easy the adjustment of two pieces of intestine of unequal size; and renders it possible to apply stitches rapidly, evenly, and securely.* Three presection sutures are inserted; a portion of bowel and a V-shaped piece of mesentery are resected, the mesenteric incision being so made as to leave a vessel uncut at each edge to supply each end of the divided intestine. The mesenteric vessels are ligated and the ends of the bowel are pulled together by the presection stitches, two of which are tied. The collapsed rubber cylinder is pushed into the bowel by means of forceps and is inflated with a syringe (Fig. 529). Twelve mattress sutures are inserted, the bag is collapsed and with-

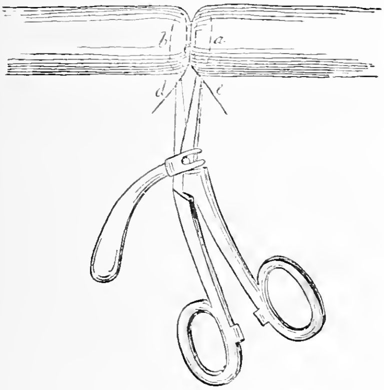


Fig. 535.—End-to-end anastomosis with the aid of Laplace's forceps.

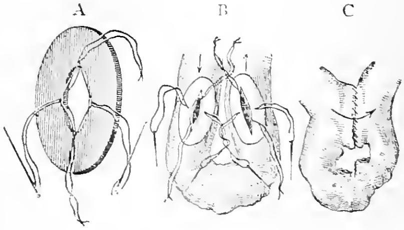


Fig. 536.—Senn's entero-anastomosis: A, Senn's bone plate; B, intestinal anastomosis; C, operation complete.

drawn and the sutures are tied, the stitch *a* being tied first (Fig. 529). The slit in the mesentery is sewed in such a way that the mesenteric vessels which nourish the bowel are not interfered with (Fig. 530).

Connell has devised a method which places the knots in the lumen of the bowel (F. Gregory Connell, "Medicine," April, 1901). He maintains that the placing of the knots within the lumen of the gut has the following advantages: there is no foreign body; the suture passes away early; adhesions to neighboring organs are few; the serous approximation is perfect; the suture-line is more secure; the septum is smaller and the danger of necrosis is less. The suture is shown in Plate 10.

Laplace has devised forceps which greatly facilitate suturing, which make it easy to obtain an even suture-line, and which can be withdrawn after the suturing is finished, the small opening through which the instrument emerged being closed with a stitch (Figs. 534, 535). By aid of Laplace's forceps the operation can be neatly and rapidly performed, but a large diaphragm is

*Phila. Med. Jour., Jan. 8, 1898.

formed, a considerable area is exposed to infection, the tissues of the diaphragm are bruised and may slough, the raw ends may grow together and

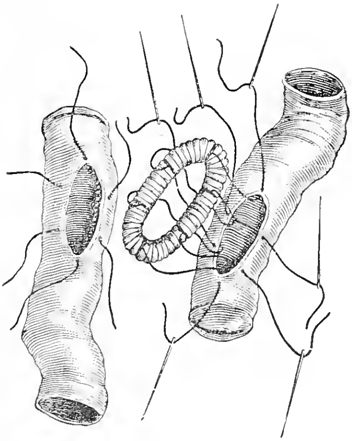


Fig. 537.—Method of passing the silk sutures in inserting the rings of Abbe.

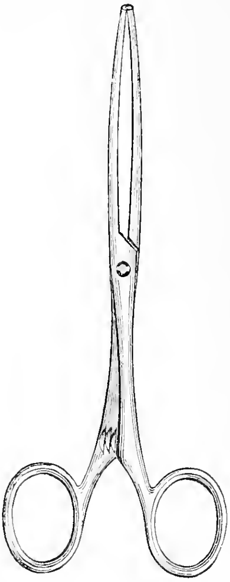


Fig. 538.—O'Hara's anastomosis forceps (about one-third original size).

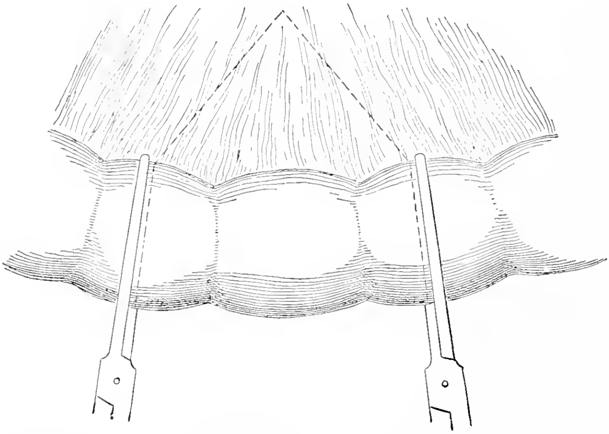


Fig. 539.—Showing the manner of placing forceps in resection of bowel; dotted lines show the incision to be made (O'Hara).

cause obstruction, and it seems probable that considerable contraction will follow. Another objection is that an infected instrument is withdrawn from the bowel and may contaminate the peritoneum. O'Hara's forceps (Fig. 538) permit

of rapid and accurate suturing, but possess the same disadvantages as the Laplace forceps. In one case within my knowledge absolute obstruction from adhesion of the raw edges of the septum followed its employment. Figs. 539 and 540 show the use of O'Hara's forceps. Of the operations previously set forth, I prefer the clamp and suture as employed by Moynihan,

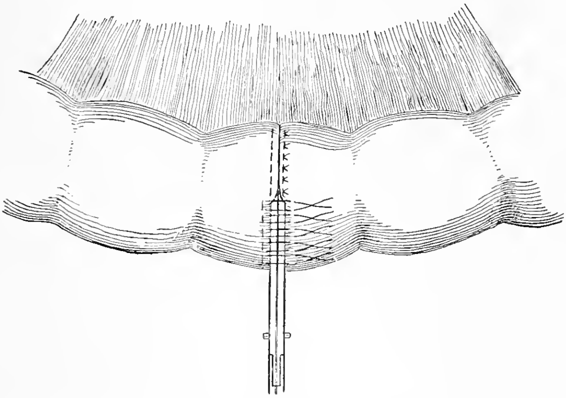


Fig. 540.—End-to-end anastomosis. Forceps brought together and held by serre-fine (not shown); sutures introduced, some of which are tied (O'Hara).

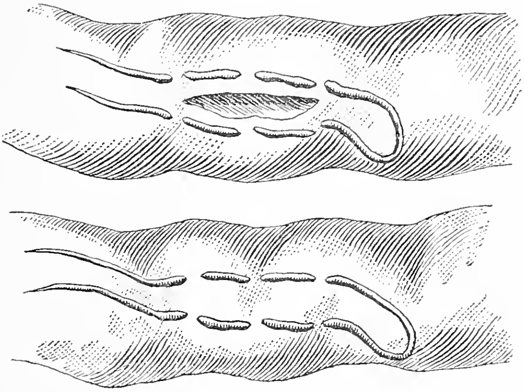


Fig. 541.—Showing relative size of incision and method of introducing sutures in lateral approximation with Murphy's button.

the operation of Halsted (although distention by an inflated cylinder is not a necessary adjunct), or the operation with the Murphy button.

Lateral Intestinal Anastomosis.—Approximation may be effected by other methods than by end-to-end junction or implantation. In fact I prefer in most cases of resection to close each end of the divided gut and perform lateral anastomosis. By this operation we can obtain as large an opening as we desire. Again, after lateral anastomosis the parts obtain

a better blood-supply than after end-to-end suturing, because in the former

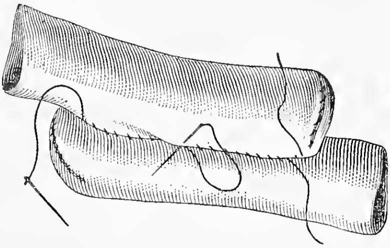


Fig. 542.—Suturing intestines in apposition before incision (Abbe).

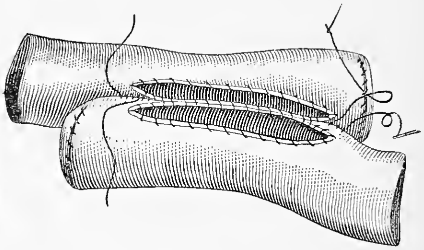


Fig. 543.—Showing the four-inch incision and sewing of the edges (Abbe).

operation the mesenteric vessels are not interfered with. Further, in lateral anastomosis there is little tendency to cicatricial contraction. Lateral anastomosis may be performed in some cases without a preliminary resection for the purpose of short-circuiting the fecal current, throwing a diseased portion of the bowel out of action, and thus avoiding obstruction (Fig. 536). This operation has the disadvantage that the diseased structure is not removed.

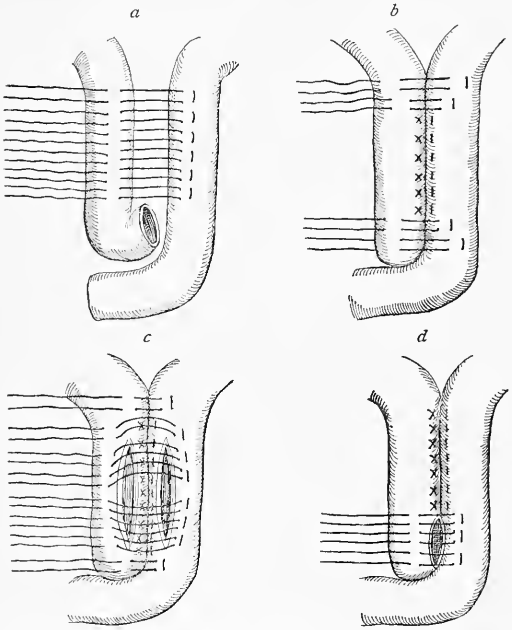


Fig. 544.—Halsted's operation for lateral anastomosis, showing four steps of same (Jessett, from Halsted).

Operation with Rings.—In this operation a portion of bowel above the obstruction and a loop below the obstruction are brought into the wound. These segments are emptied, and are kept empty by fastening around them rubber tubes or iodoform strips. Two tubes are needed for each loop of bowel. Pack in gauze pads. Make an incision in one loop, in the long axis of the bowel, on the surface away from the mesentery, permit the contents to escape externally; irrigate this segment with saline solution; and introduce the bone plate of Senn (Fig. 536, A) or Abbe's catgut ring (Fig. 537). Calyx-eyed needles are used to pass the silk, and the threads of the ring are carried through the coats of the bowel and are gathered together in the bite of a pair of forceps. The other loop of intestine is treated in a similar manner. The two segments of intestine are so brought together that the two wounds are opposite each other, the posterior

sutures being tied first, the upper next, then the lower, and finally the anterior threads. The ends of the threads are cut off and the entire anastomosis is surrounded by a layer of Lembert or Halsted sutures or is encircled by Cushing's suture. Fig. 536, B, shows an intestinal anastomosis partly finished, and Fig. 536, C, shows an anastomosis complete. Fig. 537 shows the passing of the sutures when the catgut rings of Abbe are employed. After an intestinal resection each end can be closed and anastomosis effected as described above. Lateral anastomosis can be accomplished with a Murphy button, the intestine being prepared for the button as is shown in Fig. 541.

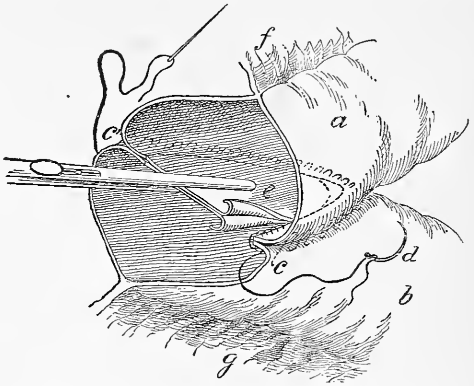


Fig. 545.—Represents the ends of the intestine in position and grasped by the artery forceps. The first row of sutures has been partially applied, the septum partly cut away, and the second row of overhand sutures begun. *a*, *b*, are the two ends of the intestine; *c*, *c'*, the first row of sutures (Cushing); *d*, the second row of sutures (overhand); *e*, the septum; *f* and *g*, the mesentery (J. Shelton Horsley).

Abbe's method of anastomosis without mechanical aid is as follows: After resecting the bowel and mesentery and closing the ends of the bowel he places the extremities side by side and applies two rows of a Dupuytren suture, one-quarter of an inch apart. These rows of sutures are an inch longer than the slit in the bowel will be (Fig. 542), the thread at the end of each row being left long. An incision is made in the bowel, one-quarter of an inch from the sutures, both rows of threads being on the same side of the cut. This incision is four inches long. The other portion of the bowel is then incised in the same way. The adjacent cut edges are united by a whip-stitch which goes through all the coats, and the free cut edges are stitched in the same manner (Fig. 543). The surgeon now utilizes the long threads of the first sutures, and brings the serous surfaces of the opposite sides together by means of Dupuytren's suture. Halsted performs anastomosis as follows: He places the two portions of bowel with their mesenteric borders in contact. Six quilted sutures of silk are introduced, tied, and cut off (Fig. 544, *a*). At each end of this row of sutures two quilted sutures are introduced, tied, and

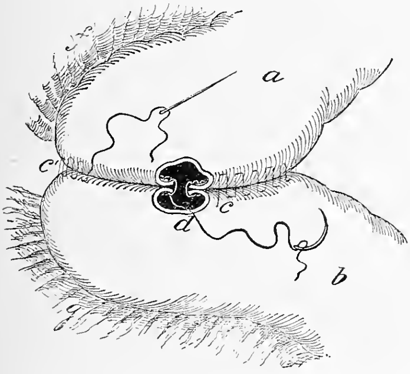


Fig. 546.—Operation nearly completed. The septum has been cut away, and the row of overhand sutures has been brought almost to its point of commencement. The cut also shows the first row of sutures (Cushing) as it should be continued after the overhand sutures are finished (J. Shelton Horsley).

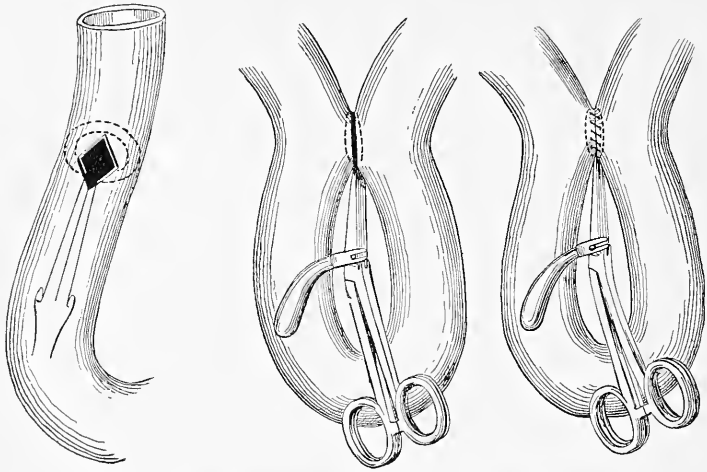


Fig. 547.—Lateral anastomosis with the aid of Laplace's forceps.

cut (Fig. 544, *b*). A number of quilted sutures are introduced, as is shown in Fig. 544, *c*. The intestinal openings are made with scissors, and the sutures last introduced are tied and cut off (Fig. 544, *d*).

J. Shelton Horsley has suggested an ingenious method of intestinal anastomosis which secures for the sutured portion a greater diameter than that normal to the intestine.* After resection of the intestine and a V-shaped piece of mesentery, the ends of the bowel are placed side by side, the openings being in the same direction, and are clamped in place (Fig. 545). The first stitch approximates the two limbs of the bowel near the mesenteric attachment, is carried obliquely for about two inches to the border opposite the mesenteric attachment, and continued over the other side (Fig. 545). The septum is cut away, a margin being left one-third of an inch wide. The edge of the shelf made by cutting the septum is sutured. When the suture reaches the end of the shelf, it is continued by invaginating about the rest of the resected ends (Fig. 546).

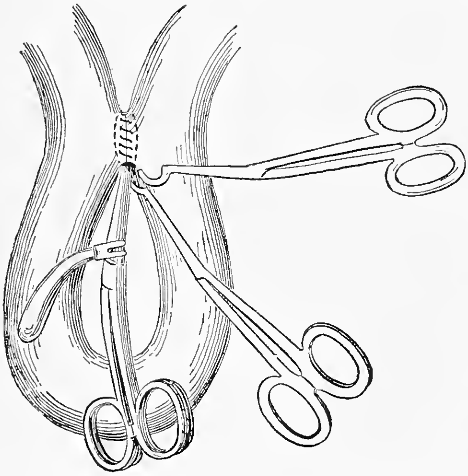


Fig. 548.—Withdrawal of Laplace's forceps.

Bodine's method of intestinal anastomosis is referred to on page 964. Laplace, of Philadelphia, has devised an operation in which temporary approximation is effected by means of forceps, the instrument being withdrawn before the abdomen is closed. Junction of two segments of intestine

*New York Polyclinic.

can be quickly and neatly effected by this method and the suture line is even and secure. The objections are that an infected instrument is withdrawn from the bowel and may contaminate the surface; that the septum is tightly squeezed and this septum may slough or may become infected, conditions which will be followed by infection of the suture line; and that contraction of the collar may ensue. The operation is more liable to be followed by leakage or by partial or complete obstruction than is the operation without forceps. Figs. 547 and 548 illustrate the use of Laplace's forceps in lateral anastomosis. I usually perform lateral anastomosis with the assistance of Moynihan's clamps, the method being identical with the operation of gastro-enterostomy. Moynihan's operation is shown in Fig. 549.

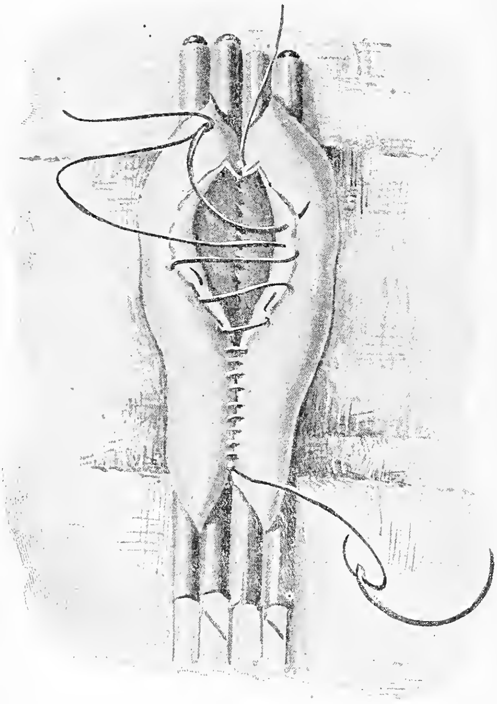


Fig. 549.—Moynihan's inner suture in lateral anastomosis to show the infolding of the mucosa which results. A loop of the suture lies on the mucous surface (Moynihan).

Consideration of Methods of Intestinal Approximation.—At least 250 methods of uniting a divided intestine have been devised and the best method is a matter of dispute. The essentials of a good method are: rapidity of execution, the formation of an even and reliable line of junction, and the absence of any considerable permanent septum. The Murphy button can be applied with great rapidity, and rapid operation is of immense importance in intestinal work. The opening left by the Murphy button is small (too small, some surgeons think), but it does not strongly tend in most instances to contract because the tissue-diaphragm is separated by tissue-atrophy and not by inflammatory gangrene. The separation of the diaphragm is a most valuable feature. No other instrument thus cuts away the objectionable septum. Occasionally the opening made by the button contracts and gives trouble; occasionally the lumen of the button blocks with feces; occasionally the button is retained, this latter complication being especially frequent after anterior gastro-enterostomy. If the button is used, liquid food should be given soon after the effect of the anesthetic has passed off, and movement of the bowels should be obtained at an early period after operation and frequent evacuations should be maintained. The button gives better results in end-to-end approximation than in lateral anastomosis. Moynihan's forceps,

Laplace's forceps, O'Hara's forceps, the decalcified bone plates of Senn, the catgut rings of Abbe, the segmented ring of Harrington, the catgut strands inside of rubber tubing of Brokaw, Chaput's button, Allingham's bone bobbin, Robson's bone bobbin, Frank's coupler, Clark's bobbin, tubes or plates of potato or carrot, and rings or plates of leather, all have their adherents. Of mechanical appliances, the best are Murphy's button, the bone ring, Moynihan's forceps, and the inflatable rubber cylinder. Of recent years many surgeons have abandoned all mechanical aids, and have returned to closure by simple sutures. The ideal operation is without mechanical contrivances. But such devices are time-savers, and to lessen the time of operation will often save life. Further, Moynihan's forceps prevent fecal extravasation and consequent infection. What method to follow must be determined in each particular case by a study of the necessities of the situation. Nevertheless, it may be possible to formulate a few general rules: If the condition of the patient is excellent and the bowel is in a fairly healthy condition, well

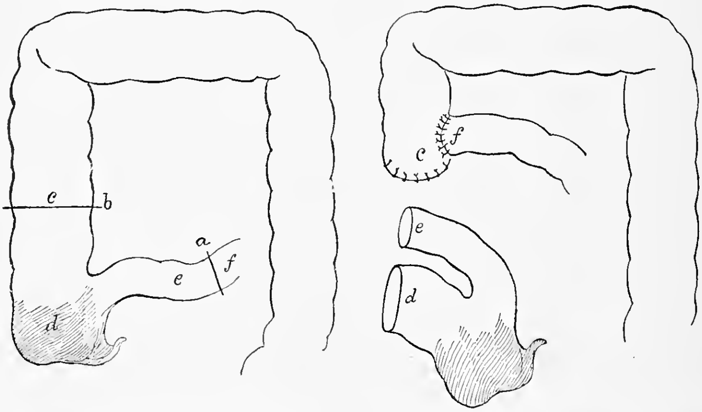


Fig. 550.—Operation of complete exclusion of the cecum : *a* and *b*, Lines of incision ; *f* is implanted into *c* ; *e* and *d* are sutured to the abdominal wall.

above and well below the seat of trouble, end-to-end approximation should be performed by circular enterorrhaphy with the aid of Moynihan's clamp, or each end can be closed after resection and a lateral anastomosis be effected with the aid of the clamp. If the condition of the patient is such as to make haste necessary, use a Murphy button. If the bowel below the seat of trouble is much contracted and haste is necessary, do not use a Murphy button, but use Senn's bone plate or Robson's bobbin. If haste is not imperatively necessary, do enterorrhaphy. If the surgeon is obliged to join a very much distended bowel to a very much contracted bowel, perform end-to-end approximation (implantation) with the bone plate of Senn or by simple suturing, or else effect side-to-side junction by the method of Abbe or of Moynihan.*

Local Intestinal Exclusion.—This operation was introduced by Salzer in 1891. It excludes the fecal current from a portion of the intestine. In complete exclusion the intestine is cut through above and below the diseased portion and the ends of the healthy gut are united to each other or the end of one portion of gut is implanted into the side of the other. Both ends

* See the discussion of this subject by the late J. Greig Smith in his "Abdominal Surgery."

of the excluded portion may be fastened to the skin, making a double fistula (Von Eiselberg); the distal end or the proximal end alone may be fastened to the skin, the other end being closed by sutures and replaced within the abdomen. Sometimes each end is closed and dropped back, and a fistula is made in the middle of the excluded portion to permit of drainage. Some operators close each end by suture and drop them back, and do not drain the excluded portion; and others aim at the same end by suturing together the two ends of the excluded part. It seems wisest to suture both ends, or at least one end to the skin (LeDentu, in "Rev. de Gyn. et de Chir.," Jan. and Feb., 1899). It is true this makes a permanent fistula, but if it is not done, the loop may become distended with secretion containing virulent bacteria, a condition which may lead to perforation and death. Exclusion is rarely performed upon the small intestine. It is best suited to the large intestine. If it is done at all, complete exclusion is the best operation (Fig. 550). Partial exclusion is rarely satisfactory. Exclusion has been performed instead of colostomy in cases of intestinal obstruction, but it is best suited to inflammatory areas or tumors, irremovable because of adhesions or some other cause. After the operation the diseased area may improve because of drainage and freedom from irritant fecal matter. In many cases it can be irrigated through the fistula. Sometimes the diseased part improves sufficiently after a time to permit of extirpation.

Surgical Treatment of Ascites Resulting from Hepatic Cirrhosis (Epiplopexy).—The portal system communicates with the vena cava by means of a number of small vessels. Normally only an insignificant amount of portal blood passes by this route to the general circulation. When cirrhosis obstructs the flow of blood through the liver, the radicles of communication between the portal system and the vena cava enlarge and an increased amount of blood is thus sent direct to the systemic circulation. Adhesions develop between the parietal peritoneum and some of the viscera and the collateral circulation is further increased. Thus, nature seeks to prevent ascites. If, however, the obstruction to the passage of portal blood becomes so great that "the collateral circulation is no longer able to maintain an equilibrium in the blood-pressure in the portal radicles, the pressure thus rises to a point at which transudation takes place and ascites develops" (M. L. Harris, paper read before Chicago Medical Society, Feb., 1902). The theory above set forth is the "mechanical theory"; but, as Harris points out, increased portal tension is not the only factor concerned in the production of ascites, chronic inflammatory changes in the peritoneum being "materially instrumental" in maintaining ascites by lessening the absorbing power of the peritoneum. Influenced by the mechanical theory of causation, Talma, of Utrecht, devised an operation to cure ascites by establishing more free communication between the portal system and the systemic circulation. Drummond and Morison about the same time devised a like procedure independently.* This operation is called *epiplopexy*. In some cases the abdomen has been opened and the omentum sutured in the abdominal wound; in others between the layers of the anterior abdominal wall. The results are slightly better when the omentum is sutured between the layers of the abdominal wall. The gall-bladder may be sutured to the

* Brit. Med. Jour., Sept. 19, 1896.

abdominal wall as well as the omentum. The liver and spleen, under surface of the diaphragm, and parietal peritoneum about the liver and spleen are usually rubbed harshly with a piece of gauze. Drainage is not to be used. It does not appear to contribute any favorable chances and it exposes the patient to the danger of infection.

The operation ought to be performed early, before the onset of chronic inflammation of the peritoneum. In a great majority of cases the operation proves futile, and not uncommonly death soon follows from complications or because the disease is very far advanced. In exceptional cases the operation proves of distinct benefit. The operation shows the least mortality and the greatest number of apparent cures when the liver is large; the greatest mortality and the fewest cures when the liver is contracted. The greatly lowered vital resistance of these patients is the imminent danger (Greenough). Renal disease, cardiac disease, other grave complications, and the absence of sufficient functionating liver substance to maintain life contraindicate operation (Greenough, in "Am. Jour. Med. Sciences," Dec., 1902).

Harris, in the paper previously quoted, collected 46 cases. Twenty-three of these were instances of alcoholic cirrhosis. Thirty per cent. were dead within fourteen days; 52 per cent. were dead within two months; 56 per cent. were dead within six months. Ascites had returned in all of those who died late. At the end of one year or longer 13 per cent. had recovered from ascites. The remaining 30 per cent. were either unimproved or were said to be improved with some ascites.

Of the group of mixed cases constituting the remainder of those Harris collected, 10 per cent. were dead in four days, 25 per cent. were dead in four months. In 40 per cent. no improvement took place. In 10 per cent. the report was too early to give any information. About 15 per cent. were free of ascites after one year or longer, and 5 per cent. were cured of intestinal hemorrhage, ascites never having been present. Greenough collected 105 operations; 42 per cent. were improved; 58 per cent. were not improved; 29.5 per cent. died within thirty days. Two years after operation 9 cases were apparently in good health ("Am. Jour. Med. Sciences, Dec., 1902).

Operation for Intussusception.—Air distention and hydrostatic pressure are uncertain; in an advanced case may rupture the gut; even in a recent case may fail or may reduce the bulk of the intussusception, but not its apex. Russell ("Intercol. Med. Jour. of Australasia," March 20, 1902) alludes to the uncertainty of the method. He used hydrostatic pressure in 5 cases. Two died and two recovered. In one case the method failed and operation was then performed. It is safer and better to operate early, but if the conservative plan is tried and fails, operation should certainly be done at once, because an early operation enables the surgeon easily to effect reduction, and also because early complications are unusual. The incision is made in the mid-line above the umbilicus. The surgeon endeavors by manipulation to reduce the intussusception by pushing it back, not by pulling it out. If the intussusception is gangrenous, perform intestinal resection and circular enterorrhaphy. The same rule maintains when malignant disease of the gut exists (D'Arcy Power). It is inadvisable to make an artificial anus. *Maunsell's operation* is suited to cases of irreducible intussusception. It is performed as follows: A longitudinal incision is made

in the intussuscipiens. The intussusception is gently pulled upon and is caused to protrude from this opening. Two straight needles threaded with horse-hair are passed so as to transfix the base, and one-fourth of an inch above the needles the intussusception is cut off. The needles are carried completely through, the sutures are hooked up in the middle and cut, and the two ends are tied on each side. These sutures unite the intussusception to the intussuscipiens. The two surfaces are now carefully approximated by sutures. The sutures are cut. The stump is replaced. The longitudinal incision is closed with Lembert sutures.*

Russell reports 16 cases operated upon: 12 recovered and 4 died. In every one of the 4 fatal cases the diagnosis was not made until the disease had lasted several days. In 2 of the successful cases the diagnosis was made late ("Intercolonial Med. Jour. of Australasia," March 20, 1902).

Senn's Operation for Fecal Fistula.—Suture the opening transversely with Czerny sutures of silk in order to prevent infection. Cleanse the surface thoroughly. Open the abdomen and separate the edges of the bowel from the parietes. Deliver the portion of bowel which contains the fistula and apply Lembert sutures over the Czerny sutures. Another method is to open the abdomen above the fistula, insert the fingers, cut out the skin and tissues around the fistula in an elliptical course, leaving them attached to the bowel, draw the bowel from the abdomen, pack gauze around, remove the tissues adherent to it, and suture the fistula transversely (Hearn).

Enterostomy is the making of an artificial anus. If performed in the large bowel, it is called *colostomy*. In some cases of intestinal obstruction it is necessary to open the small intestine, and if this is required, the artificial anus should be made as near as possible to the cecum. The nearer to the stomach it is made, the more apt is the patient to die of lack of nourishment. The anus may be made in the middle line or in the right iliac region. The bowel is fixed and opened as directed under colostomy. In acute intestinal obstruction it may be necessary to open the bowel at once. In such a case Paul's tube is very useful. Paul's tube is made of glass, is bent to a right angle, and has a rim near each end. The large tube is used in the colon, the small tube in the small intestine. A small opening is made in the intestine, the tube is introduced, and is tied in place by a silk suture which surrounds all the coats of the bowel, a gush of feces is caught in a basin, a rubber tube is fastened to the glass tube, and fluid feces are collected in a bottle and beneath an antiseptic fluid.† In from three or four days to a week the tube becomes loose and can be removed. Stewart's method of enterostomy was outlined on page 843.

Inguinal Colostomy.—**Maydl's Operation** (Fig. 551).—In this operation a vertical or oblique incision four inches long is made over the portion of colon to be incised. In all cases where it is possible, do a left inguinal colostomy. In right inguinal colostomy it is difficult to deliver the bowel as in a left inguinal colostomy, because of shortness or absence of mesocolon at this point of the colon. Right inguinal colostomy has been performed for chronic amebic dysentery. It puts the colon at rest and permits of free irrigation. It is kept open until the dysentery is well. Appendicostomy has replaced it for dysentery.

* T. Pickering Pick, Quarterly Med. Jour., Jan., 1897.
† Paul, in Liverpool Med.-Chir. Jour., July, 1892.

It has also been employed for the treatment of ulceration of the colon. After the incision on the left side the colon usually bulges into the wound, but if it does not, it may easily be found by following with the finger the parietal peritoneum outward, backward, and inward, the first obstruction it encounters being the mesocolon. Draw the colon out of the wound until its mesenteric attachment is level with the abdominal incision. Push a glass bar through a slit in the mesocolon near the bowel, and wrap the ends of the bar with iodoform gauze to prevent slipping. Instead of the bar, a piece of gauze can be employed, or a bridge of skin can be made under the bowel by suturing the two skin edges. The two parts of the flexure are stitched together by sutures which penetrate to and catch the submucous coat (Fig. 551). Stitch the serous coat of the bowel to the parietal peritoneum. Whenever possible, wait from twenty-four to forty-eight hours before opening the gut. The colon is opened by the cautery or by scissors. If the artificial anus is to be permanent, make a transverse incision through the bowel. Cut one-fourth way through the colon when it is first opened, and entirely across at a later period. If the artificial anus is to be temporary, the incision should be longitudinal. Maydl's operation has great advantages: it is quick, certain, reasonably safe, satisfactorily prevents fecal accumulation below the opening, and is rarely followed by absolute fecal incontinence. In many cases the bowels move but two or three times a day. The movements, however, come quickly with but little warning. Sometimes there is no warning. If diarrhea develops, there will be fecal incontinence as long as it lasts. An air-pad covered with gauze and held in place by a firm belt is the best form of permanent apparatus to wear.

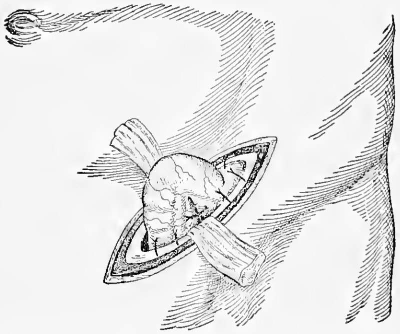


Fig. 551.—Inguinal colostomy (after Zuckerkandl).

Bodine's Operation (Fig. 552).—Bodine's method of colostomy permits of a future restoration of the fecal current by an easily performed anastomosis. This surgeon maintains that the spur after colostomy should reach to and remain at the level of the skin, a condition impossible of attainment by hanging the bowel over a rod or piece of gauze, because a spur thus formed is not thick and rigid and is inevitably dragged below the skin-level, and when this dragging has taken place, some fecal matter will pass into the bowel below the artificial anus. Bodine opens the abdomen, sutures the parietal peritoneum to the skin, seeks for the lesion, and draws it with six inches of healthy bowel out of the incision. He lays the limbs of the loop side by side. He inserts a silk stitch, beginning at the point where exsection is to be made, and for six inches unites the two segments close to their mesenteric borders. The loop is dropped into the abdomen until the beginning of the suture is on a level with the skin, and at this point it is fastened to the abdominal wound with a continuous catgut suture. The protruding lesion is cut off along the dotted line (Fig. 552). The artificial anus is thus established. When it is desired

to close the artificial anus, divide the septum with scissors or a Grant clamp (Fig. 553), and close the abdominal wound.*

Lumbar Colostomy.—Lumbar colostomy is a most unsatisfactory operation. It does not completely intercept the fecal current, and it leaves the patient in a condition of wretched discomfort because fecal incontinence is inevitable. A patient who has had lumbar colostomy performed upon him either obtains little benefit because the feces pass into the bowel below the opening which was made to intercept them or else they pour out of the opening uncontrolled, making the poor unfortunate a living horror to himself and others. It is rarely performed at the present day.

The Healthy Gall-bladder.—A healthy gall-bladder has a capacity of about 1 ounce, and its hue is bluish. If a gall-bladder contains calculi or has contained them, its hue is gray-white or yellowish (Moynihan).

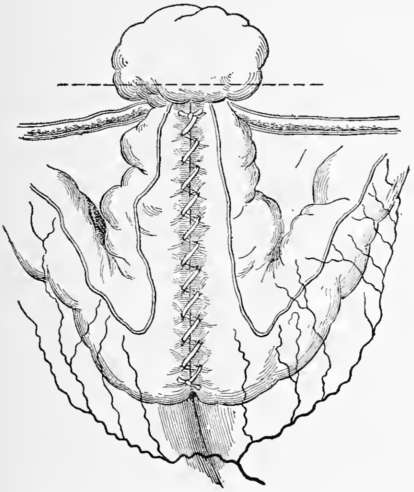


Fig. 552.—Bodine's method of colostomy, showing one side of the loop after it has been sutured, passed back into the cavity, and stitched into the abdominal wound. The lesion is left protruding, and the dotted line indicates where the protrusion is to be clipped off.

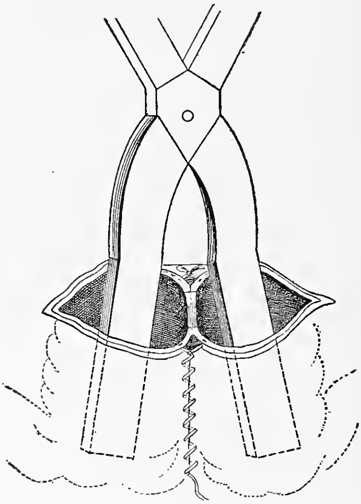


Fig. 553.—Bodine's method of colostomy, showing the septum to be divided in restoring the fecal current; Grant's clamp in position for the division. (In permanent colostomy this septum remains as a rigid and effective spur.)

The Incision for Operations upon the Gall-bladder and Bile-ducts.—I have employed several methods, but am most content with Bevan's incision (Fig. 554). The primary portion of the incision is shaped like the italic letter *ƒ*. It is by the side of or through the right rectus muscle, and is shown by the double line in Fig. 554. The primary incision is used for exploration and cholecystotomy. The primary incision is from three to four inches long, and the extended portions, shown by heavy lines in Fig. 554, are added if required (Arthur Dean Bevan, "Annals of Surgery," July, 1899). This incision gives most satisfactory exposure, its edges can be separated without tension, and it injures but few of the nerves of the abdominal walls.

Cholecystostomy, or, as many call it, **cholecystotomy,** is the operation of opening and draining the gall-bladder in order to remove gallstones or secure the removal of infectious material. In the hands

* New York Polyclinic, Feb. 15, 1897.

of the Mayos, operations for stone exhibit a mortality of less than 1 per cent. When death follows an operation on the gall-bladder or ducts, in about one-half the cases it is due to duct infection and is preceded by grave nervous symptoms (Mayo). Cholecystostomy is performed in cases of acute cholecystitis; in hydrops of the gall-bladder; in gall-stone cases in which jaundice has lasted for four weeks or more, and in colic of the gall-bladder with fever, the colic having recurred a second or third time (Carl Beck). The operation completed in one stage is performed as follows: The patient is placed recumbent with a sand-pillow under the back. Bevan's incision is made (Fig. 554). The peritoneum is opened. If the gall-bladder is distended, it is surrounded with pads and aspirated, and is then opened. Gall-stones are removed by forceps, the scoop, or irrigation. The gall-ducts are examined by the fingers external to them, and are sounded, if possible. If a stone is wedged in the duct, try to manipulate it back into the gall-bladder. If this fails, introduce an instrument from the gall-bladder and break up the stone; if this fails, open the duct, remove the stone, and close the incision in the duct (A. W. Mayo Robson). The only way to be certain that stones have been entirely removed from the cystic duct is to insert a finger and dilate. Sounds are unreliable. After the removal of all stones and fragments pass a rubber tube which has no side perforations into the gall-bladder, cut it off level with the cutaneous surface, purse up the cut in the gall-bladder around the tube by means of a catgut suture, and suture the gall-bladder to the abdominal aponeurosis. If sutured to the skin, a permanent biliary fistula is apt to follow. It will seldom follow if the gall-bladder is sutured to the aponeurosis. The gauze is now removed and the drainage-tube can usually be dispensed with in from one week to ten days. It should not be dispensed with until the bile becomes sterile.

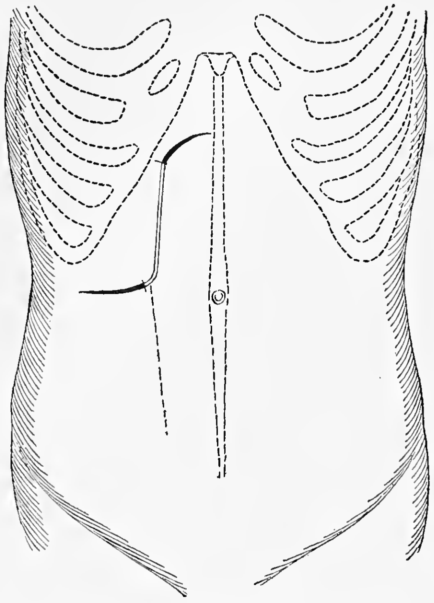


Fig. 554.—Incision for the surgery of the bile-tracts (Bevan).

Some surgeons have advocated immediate suture of the gall-bladder after removing a stone (*cholecystotomy*). I believe this is never advisable when the stones are active for harm, because small calculi may be in the ducts, and minute fragments of stone are often left in the bladder, and the drainage will remove them and relieve the diseased condition of the gall-ducts and bladder. Further, the operation with immediate suture is decidedly more dangerous when infection exists. The Mayos only employ it in latent cases of gall-stone disease when the existence of stones is discovered during the performance of an abdominal operation.

It is advised by some that the operation of cholecystostomy be performed in *two stages*. First, the bladder is exposed and sutured to the parietal peritoneum. When adhesion takes place, the gall-bladder can be opened without risk of infecting the general peritoneal surface. Riedel advocates operation in two stages, and so did Christian Fenger in certain cases. The two-stage operation is objectionable because it does not permit of satisfactory exploration of the ducts. The *biliary fistula* which is left by cholecystostomy usually closes spontaneously, but may not. If it does not close and the secretion is pure mucus, it is evident that the cystic duct is absolutely blocked and cholecystectomy should be performed.

If the secretion from a persistent fistula is bile and if the common duct is not obstructed, separate the edges of the gall-bladder opening from the parietal peritoneum, endeavoring to avoid entering the abdominal cavity, and close the fistula with Lembert or Halsted sutures. If the secretion is bile and the common duct is obstructed permanently, perform *cholecystenterostomy*. In 214 cases of cholecystotomy for stone in the gall-bladder, in the cystic duct, or both, the Mayos had 2 deaths (Wm. J. Mayo, "Annals of Surgery," June, 1902).

Cholecystenterostomy consists in making an anastomosis between the gall-bladder and intestine, preferably the duodenum. It is employed in cases of irremovable obstruction of the cystic or common duct. It is done chiefly in cases of malignant obstruction. It is not a suitable operation for gall-stones impacted in the common duct because it does not remove the cause of trouble, infection of the bile-passages is apt to follow, and the fistula is liable to contract. In those rare cases of common-duct obstruction from gall-stones in which the gall-bladder is distended and the patient is desperately ill, it may be done (Robson). In such a case Robson attaches the gall-bladder to the colon because the operation is easier and because he considers it as useful as the attachment to the duodenum. Cholecystenterostomy can be done most rapidly and successfully by means of a small Murphy button. Before the gall-bladder is incised it is aspirated. Murphy's operation is shown in Fig. 555, and is similar in performance to intestinal anastomosis.

Cholecystectomy is the extirpation of the gall-bladder. It was first performed by Langenbuch in 1882. Sometimes primary extirpation is performed, at other times, cholecystectomy is performed as a secondary operation, cholecystostomy for drainage having been first performed. Its performance may be demanded by the existence of phlegmonous inflammation or gangrene, ulceration, "in chronic cholecystitis from gall-stones where the gall-bladder is shrunken and too small to safely drain, and where the common duct is free from obstruction" (A. W. Mayo Robson), in empyema with greatly damaged walls, in fistula associated with irremediable obstruction of the cystic duct, the common duct being free, in cancer, and in some wounds of the gall-bladder. Objections to the operation are that drainage can only be obtained by putting a tube into the hepatic or the common duct and that, should renewed drainage be subsequently required, the necessary operation will prove difficult and dangerous (Maurice H. Richardson, "Medical News," May 2, 1903).

After opening the abdomen the gall-bladder is found and is drawn into the wound. If it is distended and tense or if it is thought "to contain infectious fluid" (Lilienthal), it is packed about with iodoform gauze and emptied

by an aspirating trocar. "When the walls are very friable, it is even wise to incise and empty the viscus, closing the opening by ligature or clamp before proceeding with the extirpation. The gall-bladder is usually quite a tough organ, and in the majority of cases it may be grasped with an ovarian ring-clamp applied near its fundus, which at the same time closes the aspiration puncture" (Lilienthal, "Annals of Surgery," July, 1904). The peritoneum which covers the gall-bladder must be divided just below the liver, the gall-bladder is dissected from the liver until the cystic duct is reached, the cystic artery is tied and divided, and if the liver ducts are healthy, the cystic duct is ligated with silk and divided, the stump is touched with pure carbolic acid and is covered with a layer of peritoneum fastened by sutures of fine silk. In cases free from infection it is not necessary to drain the bile-

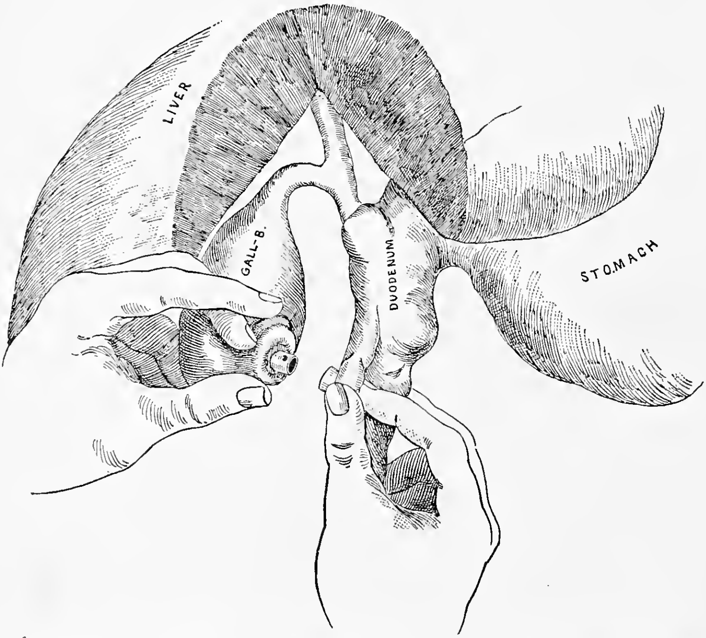


Fig. 555.—Showing method of holding parts while approximating a Murphy button in cholecystenterostomy.

ducts. In cases with cholangitis external drainage is necessary and it is obtained by incising the hepatic duct and inserting a drainage-tube, or, better, by leaving the stump of the cystic duct open. Wm. J. Mayo reports 33 cases of cholecystectomy with 1 death ("Annals of Surgery," June, 1902). Howard Lilienthal reports 42 cases with 1 death ("Annals of Surgery," July, 1904).

Removal of the Mucous Membrane of the Gall-bladder.—Mayo has suggested the removal of the fundus and of all the mucous membrane of the gall-bladder as an occasional substitute for cholecystectomy. By this operation we are enabled to drain the cystic duct and through it the hepatic ducts. A serious objection to the operation is that, as glands pass from the mucous coat to and through the muscular coat, it is impossible absolutely to remove the mucous membrane of the gall-bladder alone (Emil Ries).

Choledochotomy is the operation of incising the common duct for the removal of a stone. It is also called choledocholithotomy. It was first performed by Courvoisier in 1890.

Cases upon which this operation is done are often deeply jaundiced and there is grave danger of infection and of fatal oozing of blood. In one of my cases this happened. The patient was laboring under stones in the common duct, associated with cancer of the head of the pancreas. If jaundice exists, it is customary to endeavor to prevent hemorrhage by employing Robson's plan: Give by the mouth from 30 to 60 grains of chlorid of calcium three times a day during the twenty-four or forty-eight hours preceding the operation, and 60 grains by enema three times a day for the forty-eight hours following the operation. I use this method but am uncertain as to its usefulness.

When ready to operate, a sand-bag should be placed under the lower ribs. This will bring the liver at least two inches nearer to the abdominal wound. The abdominal incision must be longer than that employed for cholecystostomy. The pylorus and stomach are drawn to the left, the colon and omentum are drawn downward, and the liver and ribs are lifted strongly upward.

"The operator should now, after having separated adhesions, have a good view of the common duct within the free border of the lesser omentum, and on inserting his left index-finger into the foramen of Winslow, or on grasping the duct between the index-finger and thumb, he can, without difficulty, bring the duct well within reach, the concretion making a distinct projection."* A longitudinal incision is made, the stone is removed, and a probe is introduced into the duct to determine whether other stones are present.

Many surgeons suture the incision in the duct. This procedure is rendered easier by the use of Halsted's hammer, which draws the duct toward the surface and keeps it under control (Fig. 556).

Fig. 556.—Suture of duct over Halsted's hammer.

Interrupted sutures of fine silk are used. The muscular and serous coats may be included in each suture, and over this layer Lembert or Halsted sutures are applied. A drainage-tube is inserted and a piece of iodoform gauze is placed upon the suture line, the other end being brought out of the abdominal wound. This precaution is taken because leakage may occur. If it is found impossible to suture the wound in the duct, the operation then becomes a *choledochostomy* (although this term is usually used

* A. W. Mayo Robson's "Treatise on Diseases of the Gall-bladder and Bile-ducts."

only when the incised duct is stitched to the abdominal wall), and the surgeon carries a glass tube down to the opening and surrounds it with iodoform gauze, or inserts a rubber drainage-tube into the opening and carries it up toward the hepatic duct, or makes an incision into the right loin after the plan of Rutherford Morison, and carries a tube into the right kidney pouch, which is the most dependent part of the peritoneal cavity when the patient is recumbent. Personally I always drain the duct, when I have opened it for stone, carrying the tube up to the hepatic duct. The same reasons which cause us to drain the gall-bladder after removing stones should influence us in this case.

Robson ("Lancet," April 12, 1902) has performed the operation of choledochotomy 60 times. In 10 cases of stone in the common duct he manipulated the stone back into the gall-bladder and removed it through an incision in that viscus by means of a scoop. The above maneuver is impossible unless the cystic duct is dilated. In 30 cases he crushed the stones between his finger and thumb, but this is only possible when the the stones are soft, and it has the objection that it may leave fragments. If a stone is lodged in the common duct and cannot be manipulated back into the gall-bladder, choledochotomy should be performed. Robson's mortality in 60 cases of choledochotomy was 16.6 per cent. Since 1900 his mortality has been 7.1 per cent. Before that it was 23.8 per cent. In 49 choledochotomies the Mayos had 2 deaths.

Hepaticotomy.—By this term we mean the opening of the hepatic duct. If the opening is drained, the procedure is in reality *hepaticostomy*, although this term is seldom used to designate it. Hepaticotomy is performed for stone in the hepatic duct. The operation was first performed by Kocher in 1889. There were 7 cases on record in 1903 (Delagenière, in "Bull. et Mém. de Chir. de Paris," No. 10, 1903).

Duodenocholedochotomy (*McBurney's Operation; the Transduodenal Route*).—In 1891 McBurney proposed this method for the removal of gall-stones impacted near the papilla ("Annals of Surgery," Oct., 1898). McBurney's original suggestion was to open the duodenum, dilate or incise the papilla, remove the stone, and suture the duodenum. When the stone is not impacted at the outlet, but is lodged a little higher up, and when dense adhesions render access by the ordinary supraduodenal route difficult or impossible, the anterior wall of the duodenum may be opened longitudinally, the posterior wall of the duodenum and the common duct incised over the stone, the stone removed, the duodenum and common duct sutured together (*internal choledochoduodenostomy*), and the anterior wall of the duodenum closed. (See Charles Otto Thienhaus, in "Annals of Surgery," Dec., 1902.) This last-mentioned modification of McBurney's operation was first performed by Kocher. Robson opposes the transduodenal route and says he has abandoned it because of the danger of sepsis. Thienhaus ("Annals of Surgery," Dec., 1902) opposes this view of Robson and shows that in 29 operations by the transduodenal route there were but 2 deaths.

Total Splenectomy.—This operation is performed for wounds and rupture of the spleen, cysts, floating spleen, and non-leukemic splenic hypertrophy. It should not be performed if leukemia exists. In 42 cases of splenectomy for leukemic hypertrophy collected by Février ("Rev. de Chir.," Nov., 1901) there were only 4 recoveries, and in 2 of these cases the nature of the trouble was doubtful. The same author states that during the preceding ten years splenectomy has been performed for malarial spleen eighty-six times,

with a mortality of 17.4 per cent. The operation should not be performed for malarial spleen unless the organ is movable, and then, if it is done, it is for the movability and not for the malaria. It is to be noted that the operation does not cure the malaria. Février's statistics show 16 splenectomies for idiopathic enlargement of the spleen, with 3 deaths. In 46 splenectomies for rupture of the spleen there were 23 deaths (Février). In 1900 Hagan collected 360 cases of splenectomy for various conditions. In this group of cases the mortality was 38.3 per cent. The incision is from the anterior-superior spine of the ilium to the ribs (Bryant). The peritoneum is opened. Adhesions are divided between ligatures. If the spleen is adherent to the pancreas, it may be necessary to remove a fragment of the last-named organ. It is a very undesirable thing to have to do, and I lost a case from pancreatic leakage after having done it. Ligate the suspensory ligament and divide it. Bring the spleen well out of the wound. Surround it with gauze pads. Transfix the pedicle with stout silk. Tie it firmly, leaving the ends of the ligature long for a time, and cut through the pedicle beyond the ligature. Ligate the vessels separately with catgut. Cut off the long ends of the silk ligature and drop the pedicle back, unless apprehensive of bleeding, when it may be fastened to the surface. The wound is closed without drainage. Traction upon and ligation of the vessels in the pedicle may cause profound shock by injuring the splenic plexus, which is in close relation with the solar plexus (Jordon, in "Lancet," Jan. 22, 1899).

About two weeks after the removal of a normal spleen certain definite changes happen in adults but not in children. These changes last for several weeks and are manifested by enlargement of the lymph-glands, tenderness of bones, and blood-changes, loss of weight, weakness, thirst, polyuria, abdominal pain, elevation of temperature, and rapid pulse.* Tizzoni says that these changes are not obvious in children, because in them compensatory organs act at once, whereas in adults compensatory organs act slowly and with painful effort. Such symptoms are noticed when the spleen is removed because of a wound or a rupture, but rarely after removal of a diseased spleen. It is likely that compensating organs become active when the spleen is diseased, and consequently are in full operation when such a spleen is removed. After partial splenectomy these changes are not noted (Jordan). Changes can be prevented after splenectomy by the administration of tablets of extract of spleen and red bone-marrow (Ballance).

Splenopexy.—This is the operation of anchoring a movable spleen. It can only be used when the spleen is not enlarged and is not diseased. Rydygier in 1895 published the first case, although both Tuffier and Kouwer operated before this date. Sutures should not pass through the spleen itself: the structure is so soft the stitches are bound to loosen and in insertion they will cause bleeding. A promising method is to create adhesions by the use of iodoform gauze, as is done for movable kidney, and as was done by Kouwer. Some advocate making a pocket outside of the peritoneum and bringing the spleen into this pocket, thus making it extraperitoneal.

Abdominal Hernia or Rupture.—A hernia is a protrusion of peritoneum containing at times or permanently any viscus or part of a viscus from the abdominal cavity. MacCormac says the term implies that the pro-

*Ballance, in Practitioner, April, 1898; H. Martyn Jordan, in Lancet, Jan. 22, 1898.

truded viscus is covered with integument; hence a protrusion of viscera through a wound does not constitute a hernia. A hernia has three parts—the sac, the sac-contents, and the sac-coverings (Fig. 557). The *sac* is formed of peritoneum. A *congenital sac* is due to developmental defect, and is found only in the inguinal or umbilical region. An *acquired sac* is due to intra-abdominal pressure bulging the peritoneal covering of an abdominal ring and converting it into a pouch. The sac comprises a *body*, a *neck*, and a *mouth*. A sac once formed is almost certain to persist, because it adheres by its outer surface to surrounding parts, and hence the sac of a hernia is usually irreducible even when the contents are reducible. The *neck of the sac* is due to the constriction through which the sac passes; it becomes furrowed and folded, and the adhesion of these folds causes thickening and rigidity. Hernia of the bladder or of the cecum may have no sac, or but a partial sac. The *contents of the sac* depend chiefly on the situation, a portion of the ileum being the usual contents. The colon, the stomach, the great omentum, the bladder, and other structures may enter the hernial sac. An *enterocele* contains only intestine; an *epiplocele* contains only omentum; an *entero-epiplocele* contains both omentum and intestine; a *cystocele* contains a partion of the bladder. The *coverings of the sac*, which vary with its situation, will be set forth during the consideration of special forms of hernia. In old hernia the layers are never distinct, fat and muscle waste, tissues adhere, and the skin stretches and atrophies. The sac of an old hernia occasionally becomes tuberculous, and the disease may remain local in the hernia sac or spread to the general peritoneum. Renault tells us that *tuberculosis of a hernia* is made manifest by increase in size, pain on pressure, and loss of body-weight.

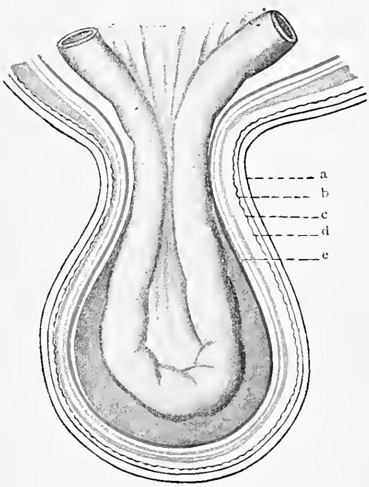


Fig. 557.—A diagrammatic representation of the coverings of a hernia (Sultan): *a*, The skin; *b*, the superficial fascia; *c*, the muscular layer—*e. g.*, the cremaster muscle in an inguinal hernia; *d*, the transversalis fascia; *c*, *d*, have also been called the fascia propria herniæ; *e*, the peritoneum—*i. e.*, the sac of the hernia.

Causes of Hernia.—Hernia is a common trouble. According to Berger, in 1000 people 4.4 per cent. suffer from hernia. It occurs at all periods of life, and hereditary predisposition sometimes seems to exist. The male sex is three times as liable to hernia as the female sex. That increase of intra-abdominal tension is a common cause in children has been amply demonstrated. (See Hernia in Childhood, page 998.) Excessive length of the mesentery has been assigned as a cause. In some instances a mass of fat forms (*fat hernia*) and advances before the hernia, and seems to bear a causative relation to it. Lucas-Championnière explains this as follows: when a person begins to take on fat, it is deposited not only under the skin, but also in the omentum, mesentery, and subperitoneal tissues. This semifluid fat is easily

influenced by pressure. The deposit of fat within the abdomen lessens the size of that cavity, intra-abdominal pressure is increased, and fat protrudes at any weak spot in the wall. The protruding mass of fat adheres to and makes traction upon the peritoneum, and this membrane is drawn upon to form a sac, and the sac is surrounded by fat. This method of formation is frequently noticed in umbilical herniæ, and occasionally in inguinal herniæ. Any laborious occupation predisposes to rupture. Any condition which weakens the abdominal wall predisposes (muscular relaxation from ill-health, relaxation of abdominal walls following the termination of pregnancy, the removal of a large tumor, or tapping for ascites, and wounds or abscesses of the abdominal wall). The common cause is repeated muscular effort which increases intra-abdominal tension (straining at stool, coughing, lifting weights, jumping, the sexual act, and straining in micturition). The sac of an acquired hernia exists for a longer or shorter time before the hernia enters it. The sac of a congenital hernia is present at birth; the sac of an acquired hernia gradually forms. A sac may exist for years and yet remain empty. When bowel or omentum enters it from some strain or effort, the parts were long prepared to receive the extruded mass.. This extrusion may occur gradually; it may occur suddenly. If it occurs suddenly, the sufferer believes that his hernia was formed then and there, but, as a matter of fact, the extrusion of bowel or omentum and its entrance into the sac are but the last of a long series of antecedent and preparatory changes. Finally, a hernia appears, and usually does so during effort. In rare cases traumatism may cause a hernia immediately, no sac existing before the accident. It does so in the inguinal region by stretching or tearing the internal ring, the inguinal canal at once enlarging. Such a condition is a true *traumatic hernia*, traumatism being the sole cause and not simply the exciting cause.

The old and erroneous idea was that a hernia was always formed by tearing of the peritoneum; hence the term *rupture*. An ordinary non-traumatic hernia, when the bowel suddenly and for the first time enters the sac, is the seat of some pain, but the pain is not disabling and the lump disappears on recumbency. In many cases the bowel or omentum gradually finds a way into the sac, and in such cases pain is usually trivial and often absent. In true traumatic hernia there are violent pain, collapse, vomiting, inability to walk and stand, and the mass does not return to the belly on recumbency, but must be reduced by taxis or operation. All congenital herniæ are due to structural defects. Herniæ are divided clinically into *reducible*, *irreducible*, *incarcerated*, *inflamed*, and *strangulated*.

Reducible Hernia.—In this form of hernia the contents of the sac can be reduced into the abdominal cavity. At a known hernial opening the patient has a smooth enlargement (narrower above than below), which began to grow above and extended downward. A distinct neck can often be felt. In enterocele, straining, lifting, or standing enlarges the mass; the protrusion becomes smaller and may disappear on lying down; cough causes impulse or succussion; the protrusion is elastic, and may be tympanitic on percussion, and on reduction the mass suddenly disappears and there is a gurgling sound. In epiplocele the mass is often irregular and compressible, and feels boggy rather than elastic; muscular effort does not have much influence in enlarging it; impulse on coughing is slight; percussion

gives a dull note, and reduction is accomplished gradually and produces no gurgling sound. In entero-epiplocele some parts of the mass are smooth, elastic, and tympanitic, others are dull on percussion, irregular, and flabby; but the diagnosis of this especial form is uncertain. The victims of reducible hernia complain of some pain on exertion, of dyspepsia, and often of constipation.

When a hernia is beginning to form, there is often *premonitory uneasiness*. The patient complains of muscular pain in the lower abdomen, and this condition may exist for weeks before it is recognized that a hernia is present. An inguinal hernia can be recognized before it protrudes from the external ring. The tip of the finger is inserted in the ring and the patient is asked to cough. If a hernia has entered the canal, succussion will be detected on coughing. In a healthy man the external ring should admit the tip of the little finger, but not the end of the index-finger. If the end of the index-finger can be made to enter the ring, that aperture is dilated, and even if there is no hernia in the canal, in future a hernia will probably descend. In a man, if the surgeon desires to examine the ring, he inverts the skin of the scrotum over the finger and carries the finger to or in the ring. When the hernia first appears, there may be pain, faintness, and some sick stomach; but often there is no pain or any discomfort.

Treatment of Reducible Hernia.—Palliative Treatment.—Prevent constipation, forbid sudden strains and violent exercise, and order a truss. The continued employment of a truss in young persons may bring about a cure. The day truss should be applied before rising in the morning and be removed after lying down at night, when a light truss should be substituted. A special truss is applied before bathing. In very fat people there is always trouble in adjusting a truss. A femoral hernia is more difficult to keep reduced than an inguinal hernia. In a hernia in which the gut is replaceable, but a portion of omentum is irreducible, it is difficult to maintain reduction of the gut with a truss, and an operation should be performed. In an oblique inguinal hernia the pad of the truss fits over the internal abdominal ring; in a direct inguinal hernia, over the external abdominal ring; in a femoral hernia, over the femoral ring at the level of Gimbernat's ligament. MacCormac's method of measuring for a truss is as follows: in either inguinal or femoral hernia start the tape from the *lower part* of the hernial opening, carry it up to the anterior-superior iliac spine of the same side, then take it around the body, one inch below the crest of the ilium, to the other anterior-superior iliac spine, and then to the upper part of the hernial opening.* A well-fitting truss will keep the hernia up even when the patient sits in a position to relax the abdominal walls and coughs and strains. A truss is always uncomfortable at first, but a person usually becomes accustomed to it. It should be kept scrupulously clean, and borated talc powder should be dusted upon the skin under the pad at least once a day. A truss which does not keep the hernia up or which causes pain does harm. Too strong a spring tends to enlarge the hernial orifice, and thus aggravates the case. Even after an apparent cure with a truss the instrument must be worn for a long time.

Radical treatment of reducible and of non-strangulated hernia seeks to

* Treves's "Manual of Surgery," "Hernia."

obtain cure by plugging the mouth of the sac or by obliterating the canal of descent. Radical operations should be performed when a strangulated hernia is operated upon, in ordinary cases of reducible hernia in

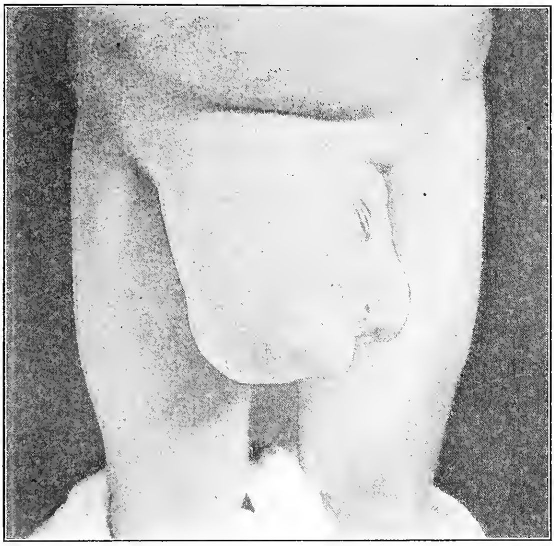


Fig. 558.—Inguinal hernia of large size (duration, sixteen years).

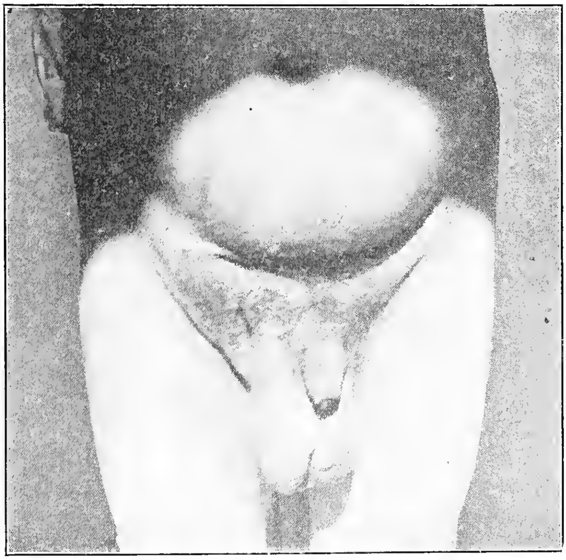


Fig. 559.—The case shown in figure 558 six months after operation.

which a truss is very painful or does not keep the bowel up, in most cases of irreducible hernia, and in any case of hernia in which there are occasional attacks of obstruction. It was formerly believed that a cure would fail if the

subject was under three years of age, but Coley and others have proved that it is a very successful operation in childhood. It is rarely recommended under the age of four, because in two-thirds of the cases a truss will cure. It is advised after the age of four when a truss has failed, when there is irreducible omentum, or when there is a reducible hydrocele which prevents the truss from folding (Wm. B. Coley, in "Annals of Surgery," June, 1903). The radical operation is almost without danger in properly selected cases, and is one of the most successful of surgical procedures. We are justified in doing the operation upon an individual under fifty years of age and free from complications, purely to relieve him or her from the annoyance of wearing a truss. If, however, a patient is sixty years of age or over and a truss keeps the hernia up satisfactorily, the operation should not be performed unless it is demanded by some complication. Organic diseases of the heart, lungs, and kidneys are contraindications. Enormous herniæ (Figs. 590, 594, and 595) are unfavorable for operation. Restoration is difficult or impossible, the forcible handling produces much shock, and recurrence is to be expected. Restoration is difficult or impossible because the abdominal cavity has contracted and holds with difficulty or cannot hold the huge hernia. As J. L. Petit said, the hernia has forfeited the right of domicile. In an operation for an enormous hernia a great quantity of omentum will require removal, and it may be necessary to resect a considerable piece of intestine. If we decide to operate upon an enormous hernia, treat the patient some time before with the object of making him lose flesh. The absorption of mesenteric fat lessens intra-abdominal pressure. That operation may succeed in such cases is shown by Figs. 558 and 559. In any operation for the radical cure of inguinal hernia always remember that the *bladder* may be part of the hernia, and be on the lookout for it. As a rule, it is covered with cellular fat, which differs in color and consistence from omental fat and from other fat which may be found about a hernia. It was the author's misfortune on two occasions to open a bladder in operating upon an inguinal hernia. In each case the bladder was sutured, and both patients recovered.

The success of an operation for the radical cure of a hernia depends upon the attainment of primary union. Primary union is favored by thorough cleanliness; by wearing gloves while operating; by cutting the parts with a sharp knife instead of tearing them with a dissector; by removing some fat and any superfluous tissue-fragments; by tying the stitches firmly, but not tightly (a tight stitch causes necrosis and creates a point of least resistance); by careful closure; by dressing with pressure; and by keeping the patient recumbent for three weeks.

A truss is not to be used after operation. Wm. B. Coley ("Annals of Surg.," June, 1903) has operated upon 1075 cases of inguinal and femoral hernia. In his report he does not consider operations performed within the last six months, and so presents a study of 1003 cases. Of these, 937 cases were inguinal, 66 cases were femoral. In the 1003 cases, 647 were traced and were found well from one to eleven years after operation; 705 were well from six months to eleven years; 460 were well from two to eleven years. If the patient is well one year after operation, he will probably remain well. This is proved by Coley's study of relapses, an investigation which shows that 65 per cent. of relapses occur within six months of operation and 80 per

cent. within the first year. Only $13\frac{2}{3}$ per cent. occur from one to two years, and only $6\frac{2}{3}$ per cent. after two years. Coley had 2 deaths in 1075 cases (less than one-fifth of 1 per cent.). After Bassini's operation there are about 1 per cent. of relapses.

Lannelongue's Method.—Lannelongue has for certain cases returned to the old injection plan, using a 10 per cent. solution of chlorid of zinc instead of white oak bark. The hernia is first reduced and is held up by an assistant who closes the internal ring with a finger, and also holds the cord aside. Several injections of 10 minims each are thrown in the region of the internal pillar, the region of the external pillar, and into the canal behind and outside of the cord. The surgeon must be careful that no zinc solution escapes into the subcutaneous tissue. The effect of the chlorid of zinc is to cause the formation of quantities of fibrous tissue. It is scarcely to be expected that a cure so produced will be permanent in an adult, though it may be in a child.

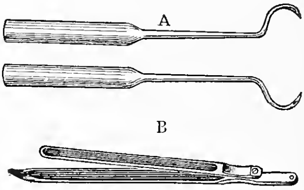


Fig. 560.—A, Hernia needles; B, hinged hernia director.

Macewen's Operation for Inguinal Hernia.—The instruments required in this operation are scalpels, a blunt, straight bistoury, a dry dissector, a grooved director, scissors, a hernia director (Fig. 560, B), hernia needles (Fig. 560, A), dissecting forceps, toothed forceps, hemo-

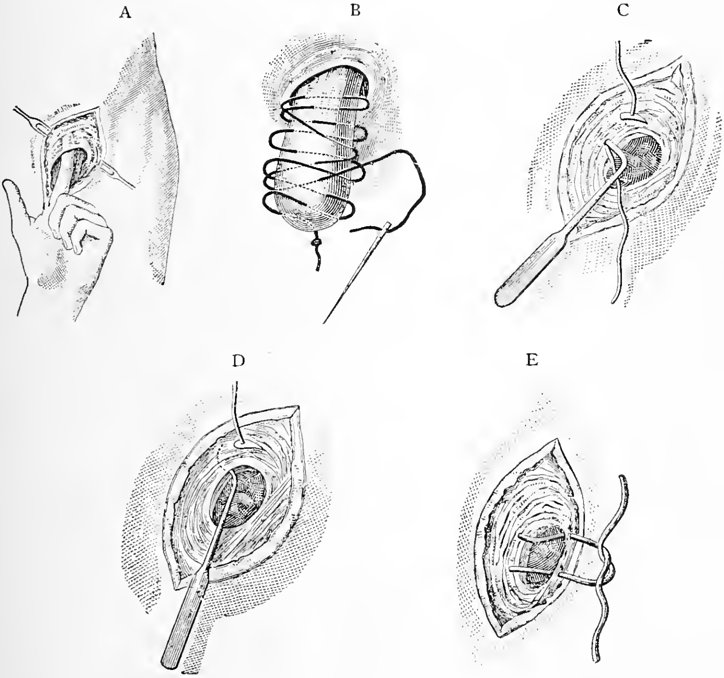


Fig. 561.—Macewen's operation for radical cure of inguinal hernia: A, Stripping of the sac; B, purse-string suture; C, fastening the purse-string suture; D, passing, and E, tying, the sutures for the internal ring.

static forceps, an aneurysm needle, blunt hooks, half-curved needles, needle-holder, and chromicized catgut sutures. The patient lies recumbent, the thigh being abducted and partly flexed and resting on a pillow beneath the knee. The bowel is reduced, and an incision three inches long is made in the direction of the inguinal canal, the center of the incision corresponding to the external ring. The sac is freed from its attachments below and is lifted up. The surgeon introduces a finger into the inguinal canal and separates the sac from the cord and from the walls of the canal, and then carries the finger through the internal ring and separates the peritoneum for one inch about the periphery of this aperture (Fig. 561, A). A chromicized catgut stitch is fastened to the lowest portion of the sac, and is passed through the sac several times, so that pulling on the stitch will purse the sac (Fig. 561, B). The free end of this stitch is carried through the internal ring into the belly, and is pushed out through the abdominal muscles one inch above the internal ring, the skin being pushed aside so as to escape perforation by the needle. The thread is tightened so as to fold up the sac and pull it into the belly. This plugs the ring (Fig. 561, C). The thread is handed to an assistant to keep tight until the sutures are introduced into the ring, when the sac is permanently anchored by taking several stitches in the external oblique muscle. A strong catgut suture is passed with a Macewen needle through the conjoined tendon from below upward, the ends of this suture being carried through Poupart's ligament and the outer border of the internal ring from within outward. This suture is tightened, and closes the internal ring. The external ring is sutured and the skin is stitched (Fig. 561, E).

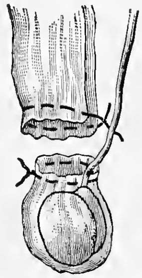


Fig. 562.—Macewen's operation for the radical cure of congenital hernia.

In congenital hernia the sac is divided in its middle, and the lower part is closed by stitches of chromicized catgut, forming a tunica vaginalis. The upper part of the sac is slit posteriorly to permit the escape of the cord, and is closed by stitches of chromicized catgut. The operation is finished as in the acquired form (Fig. 562). After Macewen's operation the patient should stay in bed for at least three weeks, and must not work for eight or nine weeks. Workmen after this operation should always wear for a time a pad and a spica bandage. Children require no pad. Never apply a truss, as strong pressure will produce atrophy of the curative scar.

Bassini's Operation for Oblique Inguinal Hernia.—(See E. Wyllys Andrews, in "Med. Record," Oct. 28, 1899, who describes from personal observation how Bassini does his operation. I have drawn upon his description in the following section.) Bassini's operation displaces the spermatic cord from the old canal and places it in a new canal, and this new canal is oblique. The instruments employed are the same as for Macewen's operation, excepting the special needles, which are not needed. Curved and rounded needles are employed to insert the stitches. The suture material is kangaroo-tendon or chromicized catgut. Silk or silver wire is apt to make trouble—it may be, long after the operation. The patient is placed supine with the thighs extended. An incision is made parallel to Poupart's ligament and extending

from the external ring to a point external to the internal ring. The incision is about one and one-half inches above the ligament and is from five to seven inches in length. By this incision the aponeurosis of the external oblique and the pillars of the external ring are exposed. All bleeding is arrested, the aponeurosis is incised in the direction of its fibers and from above downward, and the inguinal canal is opened. The aponeurosis of the external oblique is dissected up with a blunt instrument until Poupart's ligament is exposed. We speak of this ligament as the shelf. A mass containing the sac of the hernia, the cord, the cremaster muscle, and considerable fat is lifted up. Bassini employs blunt dissection. Coley advocates the use of the knife. Masses of fat and usually the cremaster muscle are removed. The sac is isolated first at its neck and the neck is stripped from the inner aspect of the internal ring for the distance of four-fifths of an inch. The object of this stripping is to permit the removal of the sac at a high level.

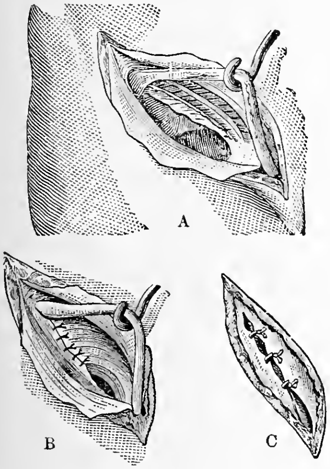


Fig. 563.—A–C, Bassini's operation for the cure of inguinal hernia.

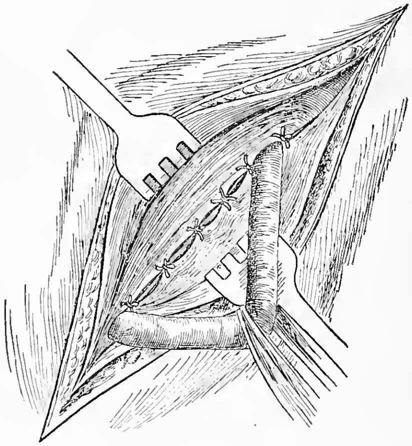


Fig. 564.—Bassini's operation (deep sutures), showing extra suture above the cord.

High removal obviates the leaving of a funnel-shaped depression of peritoneum. Such a depression predisposes to relapse. The sac is opened at the fundus, the interior is investigated, and if the contents are reducible, they are restored to the abdominal cavity and the neck of the sac is clamped high up. If adherent masses of omentum are found, the adhesions are separated, bleeding is arrested, and the omentum is restored to the abdomen unless it is in a hard and thick mass, when it is tied off and removed. Bassini ties off the neck of the sac above the clamp with a strong ligature of silkworm-gut. If the sac is large and thick, he also threads both ends of a ligature upon a needle, passes the strand through the stump, and ties around over the first loop. (See E. Wyllys Andrews, "Med. Record," Oct. 28, 1899.) Dr. Coley and many other operators prefer to tie off the sac with a catgut suture rather than with silkworm-gut or silk. It is my usual custom to employ black silk, catching it to prevent slipping by running a stitch through the wall of the neck of the sac. After ligating the neck of the sac the sac is cut

across and removed. The cord is now lifted out of the way (Fig. 563, A), the inner surface of Poupart's ligament is exposed by retraction, and the deep sutures are passed (Fig. 563, A). Bassini uses silk which has been boiled in glycerin. Most American operators use kangaroo-tendon or chromicized catgut. Bassini inserts first the sutures nearest to the pubes. The first suture —and sometimes also the second—includes part of the rectus sheath and rectus muscle. Each stitch includes the internal oblique and transversalis muscle in the upper edge and the shelf of Poupart's ligament below the lower margin, and from four to six stitches are passed behind the cord (Fig. 563, B). The last stitch narrows the internal ring so that it fits tightly around the cord (E. Wyllys Andrews, "Med. Record," Oct. 28, 1899). Coley's rule for passing this suture is to insert it so "that it just touches the lower border of the cord

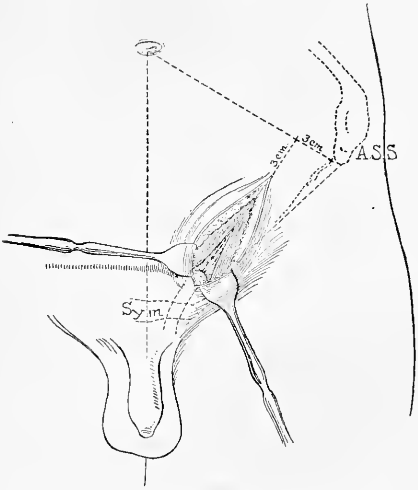


Fig. 565.—The skin incision, retractors in the lower angle of the wound dislocating the opening in the skin and subcutaneous fat downward, exposing the aponeurosis of the external oblique and external ring. The dotted line within the wound represents the direction of the division of aponeurosis of external oblique (Bloodgood).

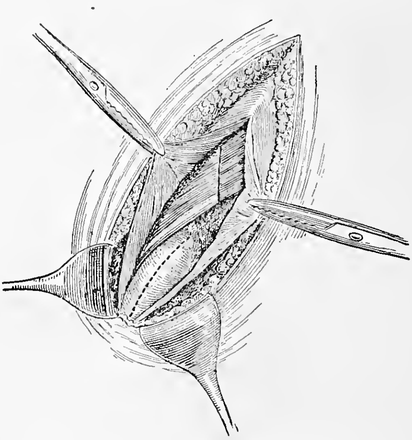


Fig. 566.—The aponeurosis of external oblique has been divided and retracted, uncovering the internal oblique muscle and inguinal canal. The lines on the muscle represent the direction and extent of the division. The dotted line in the inguinal canal is the direction and extent of the division of the coverings of sac (Bloodgood).

when the latter is brought vertically to the plane of the abdomen" ("Annals of Surgery," June, 1903). Coley always places a suture above the cord, and believes it tends to prevent relapse (Fig. 564). The sutures are tied from above downward. The cord is laid upon this new floor and the aponeurosis of the external oblique is sutured over it (Fig. 563, C). Coley uses a continuous suture of fine kangaroo-tendon and closes the skin with interrupted sutures of catgut. Drainage is not used. The wound is covered with a roll of iodoform gauze and some pieces of sterile gauze, and compression is made by strips of adhesive plaster, and a piece of adhesive plaster run from one thigh to the other acts as a shelf for the testicles to rest upon. The adhesive plaster is overlaid with dry gauze, and this is covered with absorbent cotton and the dressing is retained in place by a firm spica of the groin (*Coley's dressing*). The wound is dressed on the seventh day and the patient is kept

in bed for two weeks and is allowed to get about in two and one-half weeks to three weeks, wearing a bandage until four weeks after operation.

In this operation some surgeons treat the sac as in Macewen's operation, carrying out the rest of the procedure as directed above. In a pure Bassini operation the funnel-shaped depression in the peritoneum at the point of emergence of the cord may remain and predispose to hernia, but the use of Macewen's plan for treating the sac obviates this.

Halsted's Old Operation (as described by J. C. Bloodgood, in "Johns Hopkins Hosp. Report," vol. vii).—The skin incision is not parallel to Poupart's ligament, but at an angle of 25 degrees to it (Fig. 565). Poupart's ligament is well exposed to within 2 cm. of the pubic spine. The aponeurosis of the external oblique muscle is divided. Free the lower border of the internal oblique muscle and divide the edge of the muscle at a right angle to its fibers (Fig. 566), and as far as possible from the linea semilunaris. The coverings of the sac near the neck are picked up with mouse-toothed forceps and are divided. The division of the

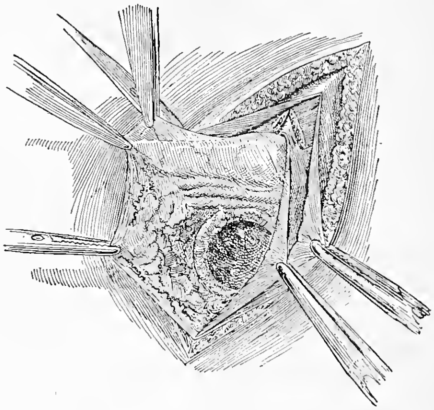


Fig. 567.—The internal oblique muscle and the coverings of the sac have been divided, the sac with the veins and vas deferens are drawn out of the wound preparatory to the excision of the sac and the ligation and excision of the veins (Bloodgood).

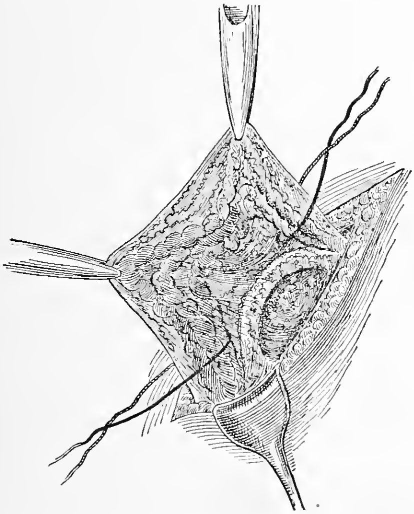


Fig. 568.—The method of excision of veins in operations for hernia and varicocele. The vas deferens and its "immediate" vessels and the mesocord have not been disturbed (Bloodgood).

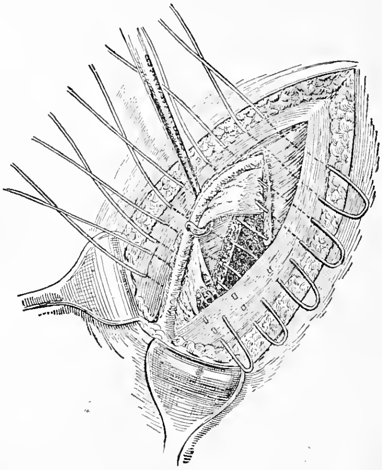


Fig. 569.—The insertion of the deep silver wire sutures, one above and four below the cord. The veins have been ligated and excised. The mesocord has been torn gently in its center only (Bloodgood).

fasciæ is continued from the neck of the sac downward toward the pubes. The sac is then lifted from the inguinal canal and it brings with it "the larger bundle of veins and the vas deferens" (Fig. 567). The sac is separated from the veins and the vas with a knife or scissors, and the separation is carried to and beyond the neck of the sac. In "*certain cases* the larger bundle of veins is separated from the vas deferens, ligated, and excised" (Fig. 568). Whether the veins are excised or not, the sac is opened, its contents reduced, the opening into the peritoneal cavity closed with a continuous silk suture, and the excess of sac excised. During the entire operation the vas and its vessels "should be handled very little, and should not be torn from their bed in the inguinal canal." Every point of bleeding should be ligated. At this stage the vas is gently picked up and a blunt-pointed hook is used to tear the mesocord. The freed vas is lifted into the upper angle of the divided internal oblique muscle, and is held there until the sutures are inserted. The deep sutures of silver wire are next inserted. Usually five are needed. The upper one is passed first. These sutures are shown in Fig. 569. The cord emerges from the cut in the internal oblique muscle between the first and second sutures. Sutures No. 1 and No. 2 pierce the mesocord, but care is taken to see that they do not injure the vas or its vessels. Each suture is drawn upon and twisted about six times. The cut twisted ends are caught with forceps and turned in. The skin-wound is closed with a subcuticular stitch of silver wire. It is covered with silver-foil and dry gauze, and often a plaster-

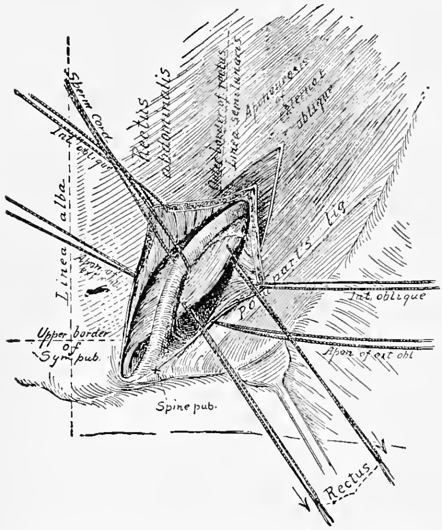


Fig. 570.—The method of transplanting the rectus muscle. The sac has been excised and the peritoneal cavity closed; internal oblique muscle has been divided, the rectus exposed and transplanted; at this stage the wound is ready for the deep sutures. This illustration shows how perfectly the transplanted rectus muscle lines the lower half of the wound (Bloodgood).

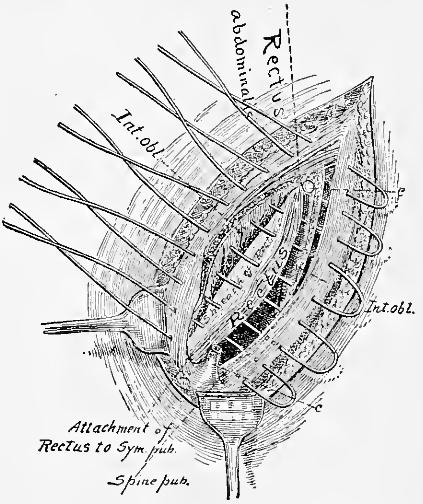


Fig. 571.—The transplanted rectus included by the deep sutures. In this illustration the cord has been excised in order to demonstrate the operation more clearly (Bloodgood).

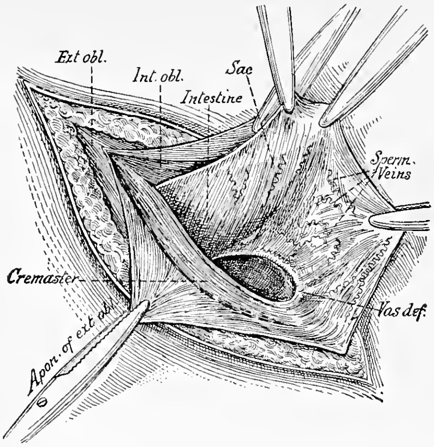


Fig. 572.—Exposure of the sac, the vas, and the spermatic veins (Halsted).

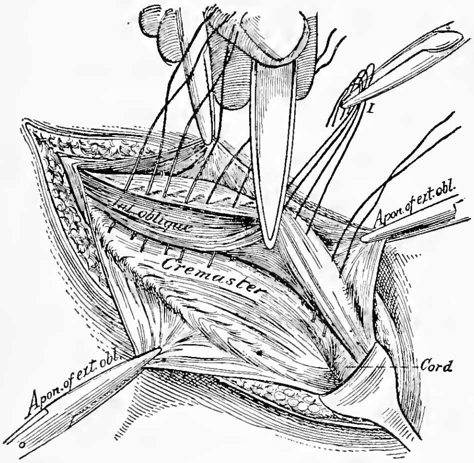


Fig. 573.—Suture of the cremaster to the internal oblique (Halsted).

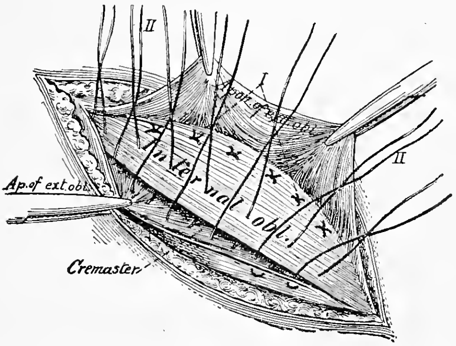


Fig. 574.—Suture of the lower edge of the internal oblique to Poupart's ligament (Halsted).

of-Paris bandage and splints are used, "the splints extending from just above the knee to near the costal margins."

The Modified Halsted Operation.—The operation at present performed by Professor Halsted and his assistants has been evolved from the former operation so long associated with his name, and has been greatly modified by himself and by Dr. Bloodgood. In this operation the skin and the aponeurosis of the external oblique are incised exactly as in performing Bassini's operation; and flaps of aponeurosis are raised. Next, the cremaster muscle and the cremaster fascia are incised in a line slightly above the center of the spermatic cord. The internal oblique muscle is then brought into distinct view at the side of the inguinal canal, and the hernia is carefully inspected (Fig. 572). If the veins are found to be large, they should be excised; but the surgeon does not lift the vas from its bed, and even avoids touching it, if he possibly can, for fear that thrombosis may occur in its veins. The veins are tied above, well up in the abdomen; and below, well above the testicle, and excised between the ligatures. The sac is then ligated or sutured with a purse-string suture. One end of the thread that ties or sutures the sac is carried, by means of a long, curved needle, in an outward direction under the internal oblique muscle, through which it is then pulled. The other end of the thread is also pulled through the muscle, one-eighth of an inch from the first end; and these two ends are tied together. It will be observed that this treatment of the neck of the sac is somewhat similar to the method practised by Kocher.

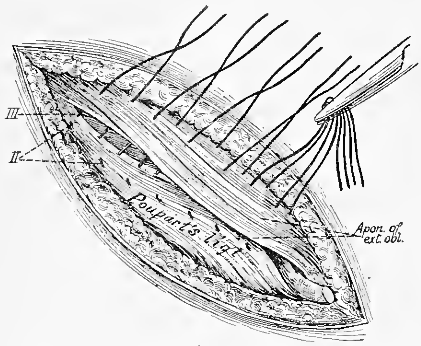


Fig. 575.—Suture of the aponeurosis of the external oblique (Halsted).

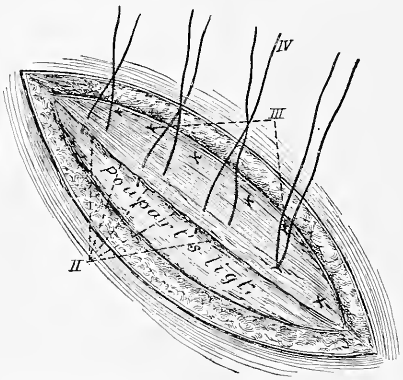


Fig. 576.—Suture of the margin of aponeurosis to Poupart's ligament (Halsted).

The next step is to carry the inferior flap, composed of cremaster muscle and fascia, under the internal oblique muscle, and suture it there (Fig. 573). We next suture the internal oblique muscle and the conjoined tendon to Poupart's ligament, the lower edge of the internal oblique being tucked under the edge of the ligament (Fig. 574). In order to accomplish this, it may be necessary to release the muscle by incising the anterior rectal sheath. The incision in the external oblique is now closed with sutures that overlap the margins (Figs. 575 and 576), and the skin wound is also closed.

Halsted's Operation plus Bloodgood's Method of Transplanting the Rectus Muscle.—(See Jos. C. Bloodgood, in "Johns Hopkins Hosp. Reports," vol. vii.) When the conjoined tendon is very thin or obliterated, the ordinary operation is not enough. Insufficiency of the conjoined tendon is known to exist when a finger does not meet any obstruction after passing through the external abdominal ring, but can be introduced for some distance into the abdominal cavity (Bloodgood). To meet this condition of affairs, Bloodgood devised "a plastic operation on the rectus muscle, bringing this muscle down and suturing it with the other available tissue to Poupart's ligament and to the aponeurosis of the external oblique from the arch of the pubis up to the position of the transplanted cord" (Bloodgood, in previously mentioned report). The first steps of the operation are identical with those previously described, but before the insertion of the deep stitches the rectus sheath is exposed and divided in the direction of the muscle-fibers, from the pubic insertion upward for 5 cm. The muscle bulges from the cut and is caught with silk sutures (Fig. 570). Deep sutures are now introduced as in Halsted's operation, except that they include the rectus and its sheath (Fig. 571). The operation is completed as is Halsted's. I have performed this operation a number of times with entire satisfaction.

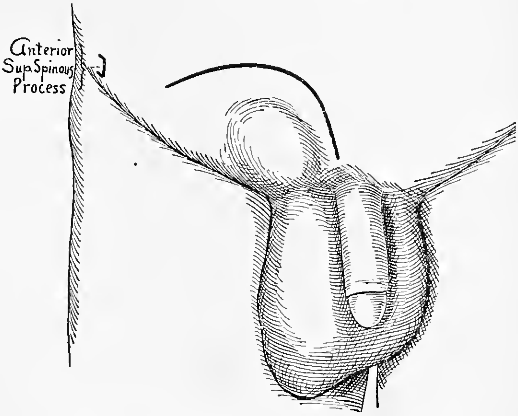


Fig. 577.—Ferguson's operation: the semilunar skin incision ("Jour. Am. Med. Assoc.").

Kocher's Operation.—Kocher exposes the aponeurosis of the external oblique, makes a small incision through the aponeurosis above and external to the internal ring, and draws the sac through this incision and sutures it in place.

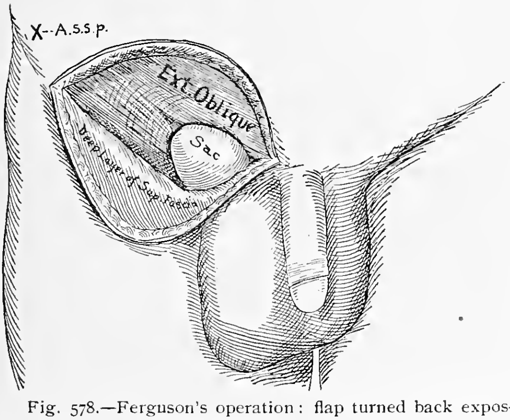


Fig. 578.—Ferguson's operation: flap turned back exposing the aponeurosis and the sac of the hernia ("Jour. Am. Med. Assoc.").

Fowler's operation is as follows: an incision is made parallel with Poupart's ligament from the spine of the pubis to the level of the internal ring, and a flap is turned up. The inguinal canal is opened and the sac and cord are isolated. The sac is opened, its contents reduced, it is cut off, and its edges grasped with forceps. The deep epigas-

tric artery and vein are sought for, each is tied in two places and divided between the ligatures. The index-finger is introduced into the belly, and on this as a guide the floor of the canal is divided (transversalis fascia, subserous tissue, and peritoneum). The cord is placed in the peritoneal cavity. The edges of the opening are sutured so that broad serous surfaces are approximated, through-and-through sutures being passed from side to side. The cord is brought out at the inner end of the incision, the lower angle of the cut being at such a level that the cord curves upward and forward as it leaves the abdomen. The inguinal canal, the gap in the aponeurosis, and the skin-wound are closed.*

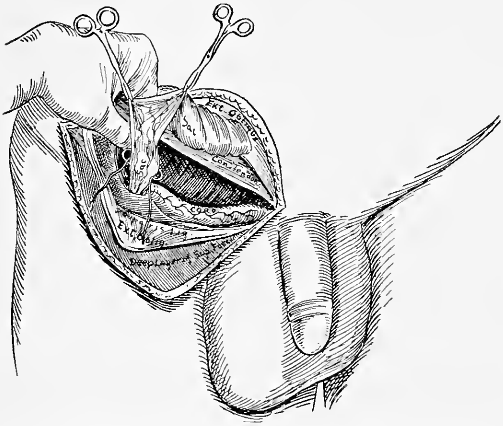


Fig. 579.—Ferguson's operation : dealing with the sac and its contents ("Jour. Am. Med. Assoc.").

Ferguson's Operation.—In studying a number of recurrences after operation A. H. Ferguson observed that a hernial protrusion is apt to return at the upper and outer portion of the scar, above the cord and near Poupart's ligament. When he operated upon relapsed cases, he discovered a slit of the aponeurosis of the external abdominal wall, through which the sac and some fat protruded. In order to determine the cause of the failure of these operations, he thought it proper to make a semilunar incision, and raise a flap of skin, fascia, and aponeurosis of the external oblique. On doing this, he was surprised to find an angle between the lower border of the internal oblique muscle and the inner aspect of Poupart's ligament absolutely unprotected by the internal oblique or the transversalis muscle. In some cases this angle extended upward and outward to the anterior superior iliac spine. He therefore determined positively that the cause of a rupture returning in this angle after an operation for radical cure is deficient origin of the internal ob-

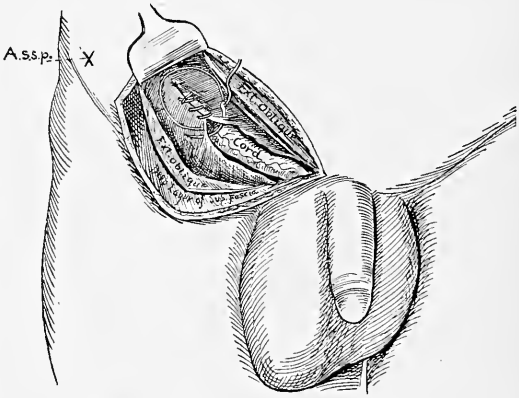


Fig. 580.—Ferguson's operation : suture of the slack in the transversalis fascia ("Jour. Am. Med. Assoc.").

*Annals of Surgery, Nov., 1897.

lique muscle and of the transversalis muscle at Poupart's ligament. He is now persuaded that in all cases of hernia there is a deficient origin of these muscles, and he has demonstrated the same thing in a series of dissections in the inguinal region. Ferguson describes his operation as follows ("Jour. Am. Med. Assoc.," July 1, 1899): He begins his incision over Poupart's ligament, an inch and a half below the anterior-superior iliac spine, carries it inward and downward in a semilunar curve, and terminates it over the conjoined tendon, near the pubic bone. This incision goes down to the aponeurosis of the external oblique, and the flap, with its fat and fascia, is turned downward and outward (Figs. 577 and 578). The next step is to incise the external abdominal ring to the intercolumnar fascia and separate the longitudinal fibers of the external oblique over the inguinal canal to beyond the internal ring, at a point nearly opposite the anterior-superior spine of the ilium. Any transverse fibers that may be encountered are severed. The separated aponeurosis of the external oblique muscle is then retracted. One has then brought into view the contents of the inguinal canal, the hernial sac and its adhesions, the spermatic cord, the ilio-inguinal nerve, the internal abdominal ring, the subserous fat, the cremaster muscle, the conjoined tendon, the internal oblique and its deficient origin at Poupart's ligament, the transversalis fascia, and the internal surface of Poupart's ligament. The sac is now dissected from the cord and the internal ring. It is opened and its contents are inspected and properly dealt with. It is tied high up and cut off, and the stump is dropped into the abdomen (Fig. 579). If the sac is congenital, it is divided into two parts: the distal portion is used to make a tunic for the testicle, and the proximal portion is treated as above directed. The cord is not disturbed, and it is beyond doubt that Ferguson is right in saying that the testicle frequently comes to harm after operations that disturb the cord. The veins in the cord should not be touched unless a varicocele also exists. Any excessive quantity of subserous adipose tissue should be removed. The next step in the operation is to restore the structures to their normal position; and one should remember that in the transversalis fascia is the internal ring. In hernia the internal ring is large and the transversalis fascia bulges outward; one must, therefore, take up the slack in this fascia and make a well-fitting ring for the cord, by means of a catgut suture, either interrupted or continuous (Fig. 580). After this has been accomplished, the internal oblique and transversalis muscle are sutured to the internal aspect of Poupart's ligament, after the lower borders of the muscles have been freshened and Poupart's

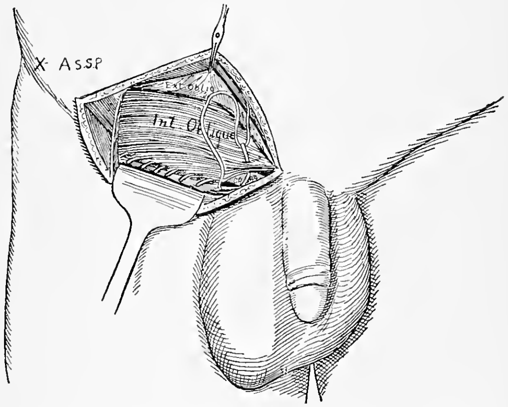


Fig. 581.—Ferguson's operation: suture of the internal oblique and of the transversalis muscle to the internal aspect of Poupart's ligament ("Jour. Am. Med. Assoc.").

ligament has been scarified. The sutures must be carried two-thirds of the way down Poupart's ligament, which is about the normal origin of this muscle in the female (Fig. 581). The next step is to suture the edges of the divided aponeurosis of the external oblique; this restores the external abdominal ring. The skin-flap is then carefully sutured.

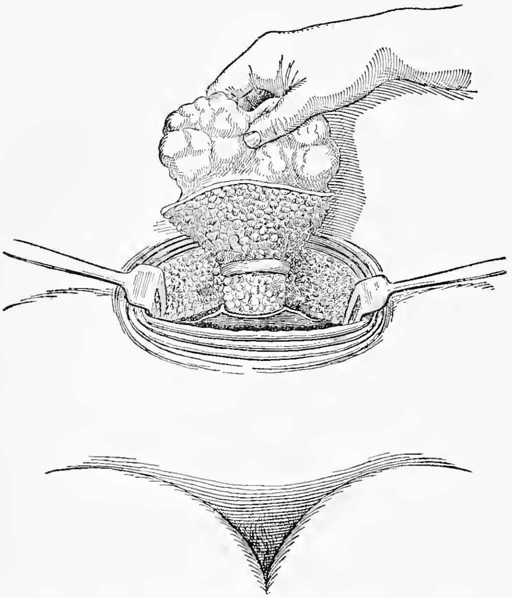


Fig. 582.—Mayo's operation for the radical cure of umbilical hernia. Exposure of hernia and lateral incisions.

Radical Cure of Umbilical Hernia.—The results of operations for umbilical herniæ have not been satisfactory. Recurrences are frequent. This is probably due to the fact that most of the subjects are fat, and that the muscles are thin and flabby. The usual operation may be thus described: Make a longitudinally elliptical incision through the skin around the mass. Endeavor to separate the sac from the superficial tissue. If this cannot be done, open the sac and separate it from the contents. Even if the sac can be stripped from the skin, always open it and separate the contents. Return any bowel which may be present, and do not forget that there may be a small portion of bowel completely encased in omentum. Tie into segments and cut off the superfluous omentum and return the stump into the belly. Excise the umbilicus (*omphalectomy*). Suture the peritoneum with a continuous catgut suture. Close the musculofascial wall with two layers of interrupted kangaroo-tendon sutures or one layer of silver wire mattress sutures. Close the skin by interrupted sutures of silkworm-gut or a subcuticular stitch.

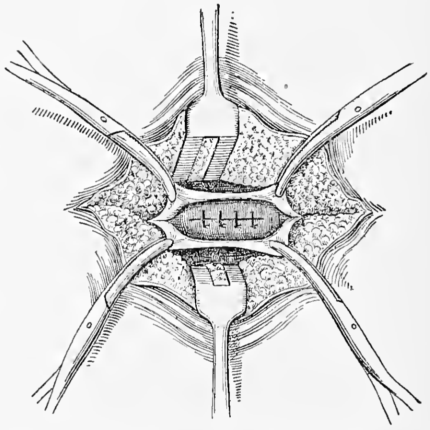


Fig. 583.—Mayo's operation for the radical cure of umbilical hernia. Peritoneum sutured.

Mayo's Operation.—This is a distinct improvement on the older operation. Mayo believes that the defect in the old operation is that the recti muscles are naturally sep-

arated at the level of the umbilicus, and in bringing the recti together we have virtually performed muscle transplantation, and these thin muscles are of no great value in preventing relapse, and in a large hernia it

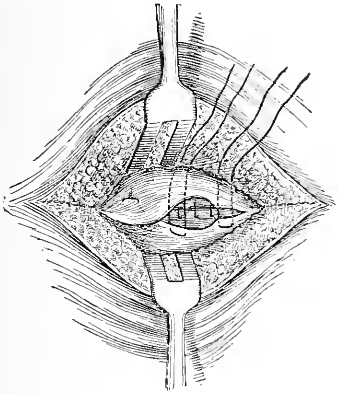


Fig. 584.—Mayo's operation for the radical cure of umbilical hernia. Aponeurosis sutured.

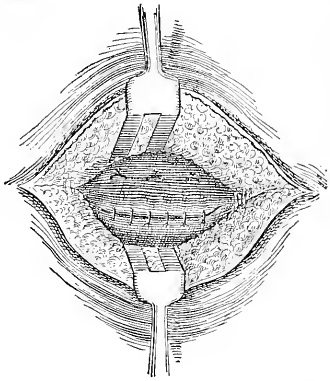


Fig. 585.—Mayo's operation for the radical cure of umbilical hernia. Aponeurosis sutured second time with gut sutures.

is not even possible to cover the gap by muscle. Mayo now operates as follows: Transverse elliptical incisions are made around the umbilicus and hernia and the base of the protrusion is exposed (Fig. 582). The surface

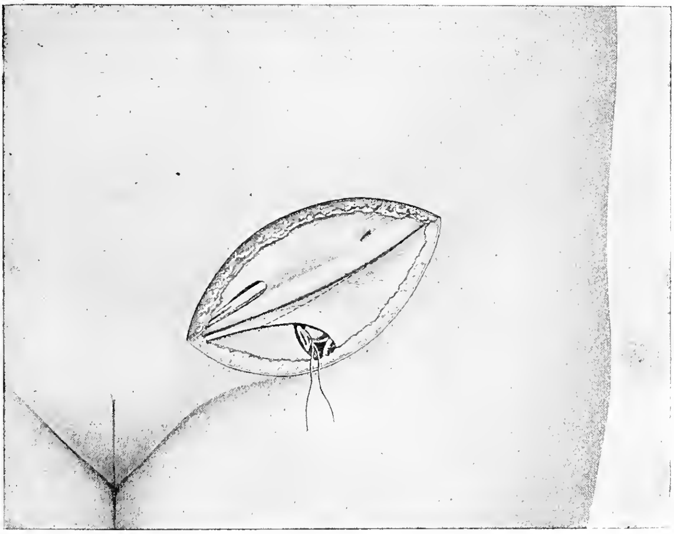


Fig. 586.—Fabricius's operation for the radical cure of femoral hernia. Neck of sac shown. Sac cut away. Dotted line shows line of separation of Poupart's ligament and fascia lata (Fowler).

of the aponeurosis is cleared for one and one-half inches around the neck of the sac. The fibrous and peritoneal coverings of the hernia are divided by a circular incision around the neck of the sac. Intestine is freed from

adhesions and placed within the abdomen. Omentum is ligated and removed with the sac. The margins of the ring are grasped and overlapped

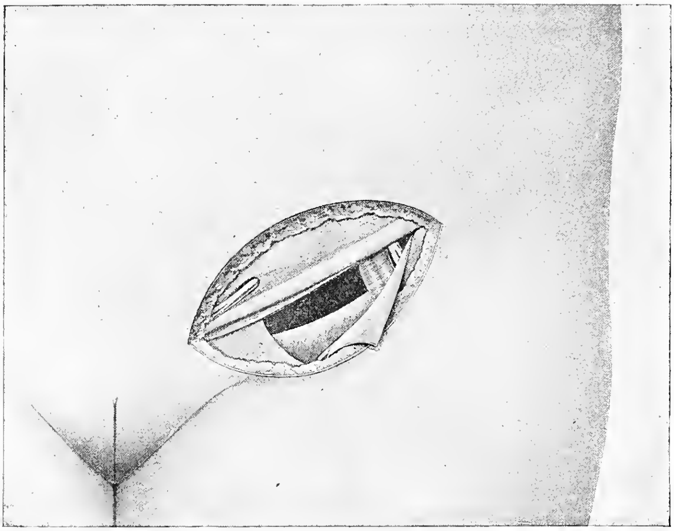


Fig. 587.—Fabricius's operation for femoral hernia. Fascia lata turned back, exposing crural sheath and origin of pectineus muscle (Fowler).

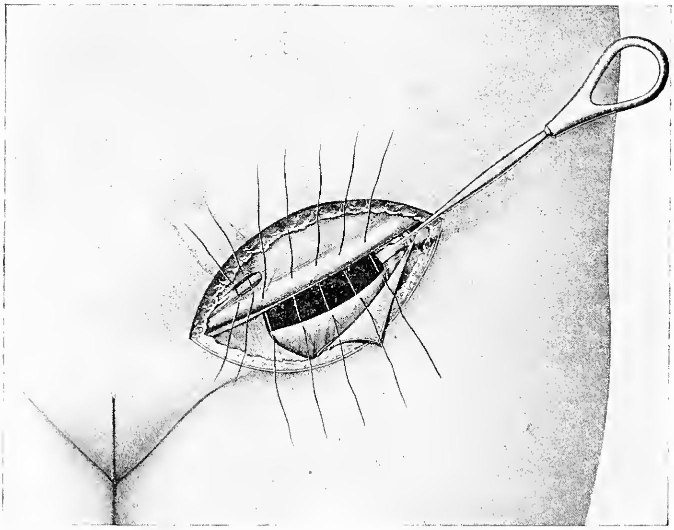


Fig. 588.—Fabricius's operation for femoral hernia. Crural sheath and vessels retracted and kangaroo-tendon sutures applied to Poupart's ligament and origin of pectineus, ready for tying. Two sutures are placed in position to approximate the pillars of the external ring (Fowler).

in order to indicate in which way it can be most easily done. Thus is the direction of the closure indicated. An incision is made through the fibrous and peritoneal coverings of the ring, one inch or more transversely on each

side, and the peritoneum is stripped from the under surface of the upper flap. Several mattress sutures of silver wire are introduced one inch above the edge of the upper flap and are carried through the margin of the lower flap; sufficient traction is made to permit of the closing of the peritoneum with a continuous catgut suture (Fig. 583). When this has been accomplished, the silver wire sutures are drawn so as to slide the lower flap into the pocket between the peritoneum and the under surface of the upper flap (Fig. 584). The free margin of the upper flap is fixed by catgut sutures to the aponeurosis (Fig. 585), and the superficial incision is closed as usual.

Radical Cure of Femoral Hernia.—Cheyne ligates the neck of the sac, stitches the stump to the abdominal wall, dissects out a flap from the pectineus muscle, stitches this flap to Poupart's ligament and to the abdominal wall, and thus fills up the crural canal. Bassini makes an incision parallel with Poupart's ligament, ties the neck of the sac, cuts below the ligature, and returns the stump into the belly. He attaches by deep sutures Poupart's ligament to the pectineal aponeurosis as high up as the pectineal eminence, the cord or round ligament being drawn out of the way. Superficial sutures are passed between the pubic portion and the iliac portion of the fascia lata.

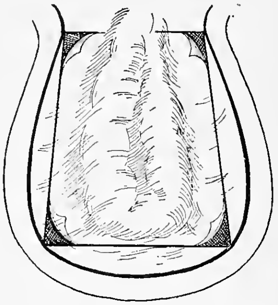


Fig. 589.—Outline of peritoneal lining of sac utilized as a flap to cover posterior surface after it has been freed by dissection (Weir).

The Operation of Fabricius.—The operation of Fabricius is very satisfactory. It is performed as follows: An incision is begun over the pubic spine and is carried outward for five inches parallel with Poupart's ligament. The sac is exposed, isolated, and opened, and its contents are reduced, its neck is ligated, the sac is cut off, and the stump is dropped back (Fig. 586). An incision is now made below Poupart's ligament so as to separate this structure and the fascia lata, and the flap of fascia is turned down (Fig. 587). The crural sheath and the vessels are retracted outward. The surgeon is careful not to injure the obturator artery and vein. The origin of the pectineus muscle is sutured to Poupart's ligament. The lower stitches include the periosteum of the horizontal ramus of the pubes as well as the beginning of the muscle (Fig. 588). Care must be taken in passing some of them to avoid injuring the deep epigastric vessels. When these stitches are tied, the femoral canal is obliterated. The flap of fascia lata is sutured to the aponeurosis of the external oblique, and the skin is sutured.

Operative Treatment of Sliding Hernia of the Ascending and Descending Colon.—My personal experience consists of three cases of right inguinal hernia. It will be remembered that the sac is deficient posteriorly and externally. In order to restore the bowel many operators have sought to force up the adherent bowel to the external ring, and others have stripped the bowel from the subperitoneal tissues in order to permit of reduction. This first plan should never be followed, as sutures will fail to hold the bowel up. The second plan is risky and may be followed by gangrene of the bowel. In my 3 cases I followed Weir's plan ("Med. Record," Feb. 24, 1900), and after

dissecting up the peritoneum on each side to a little above the internal ring, freed the bowel from its bed, and covered the new surface with the peritoneal flaps (Fig. 589). The bowel was then restored and a radical cure was made.

Irreducible Hernia.—The swelling in irreducible rupture presents the usual evidences of hernia, imparts an impulse on coughing, but cannot be replaced in the abdomen. Sometimes a portion is reducible and a portion is irreducible. A hernia may become irreducible because of the size of the mass, because of adhesions, or because of excessive growth of omental fat. An irreducible hernia is liable to be bruised and to cause much distress and pain, and is always a menace to life because of the danger of obstruction and strangulation. It was formerly the custom to support a small irreducible hernia by a hollow, padded truss, but at present operation is advised. A large hernia of this variety, if operation is refused, must be carried in a bag truss. The patient must not take very active exercise, must keep the bowels regular, and must live upon a plain diet. Most cases of irreducible hernia should be treated by operation.

Incarcerated or Obstructed Hernia.—Obstruction takes place by the damming up of feces or of undigested food, the fecal current being arrested, but the blood-current in the wall of the bowel not being cut off. Incarceration is commonest in irreducible hernia, umbilical hernia, and during the existence of constipation. The hernia enlarges and becomes tender, painful, and dull on percussion; pressure diminishes it in size; it is irreducible, but still presents impulse on coughing. The abdomen is somewhat distended and painful; there are nausea, constipation, and not unusually slight vomiting. Constitutional disturbance is trivial and constipation is not absolute, gas at least usually passing. Vomiting is not fecal. The *treatment* is rest in bed in a position to relax the belly, an ice-bag over the hernia for a very few hours, and a little opium for pain. Do not give a particle of food for twenty-four hours; when the active symptoms subside, give an enema, and after this acts a dose of castor oil. Do not employ taxis, as bruising the bowel may produce strangulation. If improvement does not rapidly occur, operate. Prompt operation saves the patient from the danger of strangulation and cures the hernia.

Inflamed Hernia.—Inflammation of a hernia is local peritonitis due to injury of an irreducible hernia. The mass becomes tender and painful, and perhaps heat is noted. In enterocele much fluid forms; in epiplocele the mass becomes hard. The hernia cannot be reduced; there is constipation, often vomiting, usually elevated temperature, but the mass still shows impulse on coughing. Vomiting is not fecal. Some gas is usually passed through the bowels. Constitutional symptoms are slight. The *treatment* usually recommended is rest in bed with abdominal relaxation, an ice-bag to the tumor for a few hours, a small amount of opium by the mouth if pain is severe, an enema, and, after this acts, a saline. In an inflamed hernia there is great danger of strangulation, and operation should be performed in preference to relying upon the conservative plan.

Strangulated hernia is a condition in which, if the hernia contains bowel, not only is the fecal circulation arrested and gas prevented from passing, but the circulation of blood in the bowel-wall is also arrested. The bowel is irreducible and obstructed, and the blood ceases to circulate. If the hernia contains omentum, the omental vessels are tightly constricted. In both bowel and omentum gangrene soon occurs. Strangulation is commonest in

old inguinal ruptures in active, middle-aged men, and is more frequent in enteroceles than in epiploceles. It is most common when the hernial orifice is small and is seldom seen in large ruptures.* Strangulation is much more dangerous if bowel is present in the sac than if only omentum is present. If the abdominal pressure is suddenly increased, as by a violent cough or a muscular effort, the hernial orifice is dilated for a moment, more intestine or omentum may enter the sac, and if it does, it may be caught and constricted by the now constricted hernial orifice and strangulation begins. Strangulation so caused is called *elastic strangulation.* A sudden increase of intra-abdominal pressure may force a quantity of fecal matter into the herniated intestine. The sudden entry of a quantity of fluid and gas into the herniated coil causes *fecal strangulation,* the mechanism of which is obscure. Strangulation may be due to active peristalsis or to congestion, and it may arise from inflammation or from incarceration. The constriction is usually at the neck of the sac, in the outside tissues, or even in the sac itself. In an hour-glass hernia the constriction is in the body of the sac. Adhesions within the sac may cause strangulation. Spasmodic contraction of the tissues about the neck of the sac is an exploded hypothesis. The obstructed veins dilate and the blood in them ceases to move, the bowel becomes deep bluish and finally black, effusions of blood occur beneath the peritoneum, and the intestinal wall becomes edematous. Fluid transudes into the sac and the fluid, at first clear, assumes a bloody hue, and finally becomes dry and foul. The peritoneum ceases to glisten, becomes dry and rough and coated here and there with lymph. Strangulated omentum undergoes edema and hemorrhagic infarction and thrombosis occurs. When strangulation once begins, the hernia swells, a furrow forms on the bowel at the seat of constriction, the bowel and omentum below the constriction become deeply congested and edematous, and, finally, the hernia passes into a state of moist gangrene (Fig. 591). The gangrene may be in spots or the entire mass may be gangrenous. The mucous membrane may be gangrenous when the serous coat looks fairly sound. When gangrene is once established, the bowel is in danger of rupturing. At the point of constriction there may be a line of ulceration or of gangrene. A strangulated femoral hernia becomes gangrenous more rapidly than does a strangulated inguinal hernia.

Fig. 590.—Strangulated umbilical hernia containing nearly all the intestines and part of the stomach. Strangulation under bands within the sac.

* Strangulation developed in the large herniæ shown in Figs. 558 and 590.

Symptoms.—This condition is sometimes preceded by diarrhea and uneasiness or pain about the hernial orifice. When strangulation begins, the victim is seized with pain in and about the hernia and with violent colicky pain about the umbilicus, and the paroxysms of colic become more and more frequent, until finally the pain may become continuous. The hernia is found to be irreducible; larger than usual, tender, painful, dull on percussion, without impulse on coughing, and the skin above it may be reddened. Eructations of gas are frequent and generally uncontrollable vomiting and prostration come on. Vomiting, as a rule, is an early symptom, and one which increases in severity. Occasionally it only follows the swallowing of liquids. Not unusually there is retching rather than vomiting. In rare cases vomiting does not begin for twenty-four to forty-eight hours. During the course of a strangulation vomiting may cease for a day or more, and it not unusually ceases toward the end, when prostration is profound. The early vomiting is due to reflex causes; the later vomiting is due to waves of peristalsis which produce regurgitation (Macready). The vomiting is first of the alimentary contents of the stomach, next of mucus and bilious matter, and finally of the contents of the small bowel (*fecal* or *stercoraceous vomiting*). Stercoraceous vomiting rarely arises until strangulation has lasted forty-eight hours, and may not appear until much later. "It is seldom met with in inguinal, more often in femoral, and more often still in obturator hernia" (Macready). Prostration is a marked symptom of a strangulated hernia, and it increases hour by hour and goes on to collapse. Early in the case there may be some elevation of temperature, but later it becomes normal or subnormal. The pulse is small, irregular, rapid, and very weak; the extremities cold; the face Hippocratic. Constipation is absolute, no gas even being passed, though in the very beginning there may be some diarrheal passages from below the constriction. The urine is scanty and high-colored, and contains only a small amount of the chlorids; the tongue becomes dry and brown; the thirst is torturing; and the patient often has an imperative desire to go to stool. Pains in the abdomen and in the hernia become more and more violent, and collapse rapidly increases. When gangrene begins, the symptoms apparently lessen in violence: there is a "*delusive calm.*" Vomiting usually ceases, though regurgitation may take its place; hiccough begins; the pain abates or disappears; the pulse becomes very frequent, feeble, and intermittent; collapse deepens, and delirium is usual. It is a safe clinical rule that in strangulated hernia cessation of pain without the relief of constriction, the disappearance of the lump, or the use of opiates means that gangrene has begun. In some cases of strangulation there are muscular

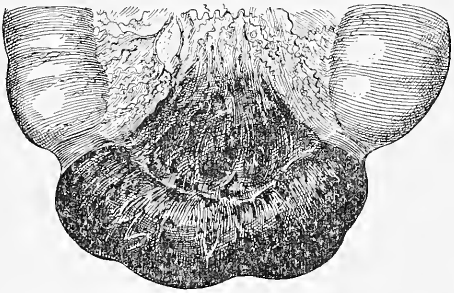


Fig. 591.—A strangulated coil of intestine after the strangulation existed for a considerable period of time. The color has become almost black and the peritoneal surface is dull and covered with flakes of fibrin. The constriction-rings are deeply sunken, their walls markedly thinned, relaxed, and dirty gray in color. Both constriction-rings are gangrenous and hemorrhages are observed in the mesentery (Sultan).

cramps in the legs (Berger). In children convulsions are not unusual. In a pure omental hernia strangulation produces similar but less decided symptoms. It may be that only a portion of the circumference of the bowel is caught and constricted in a hernial orifice (Fig. 601, A). Such a condition is encountered occasionally in the femoral ring, and is called *partial enterocele* or *Richter's hernia*. The name *Littré's hernia* is often wrongly given to this condition. What Littré described was a hernia of Meckel's diverticulum (Fig. 601, B). In a strangulated Richter's hernia constipation is rarely absolute and a protrusion is often undiscovered.

Treatment.—In treating strangulated hernia place the patient upon his back, bend the knees over a pillow, and rigidly interdict the administration of food. An attempt is to be made to effect reduction by gentle manipulation or *taxis*. In applying taxis to a femoral or inguinal hernia, flex and adduct the thigh of the affected side. In applying taxis to an umbilical hernia, both thighs should be flexed upon the abdomen. Always lower the shoulders and head and raise the pelvis, and accomplish this by lifting the foot of the bed and placing pillows under the pelvis. In some cases raise the entire body and lower the head. Grasp the neck of the sac with the fingers and thumb of one hand, and employ the other hand to squeeze the hernia and urge it toward the belly. In direct inguinal hernia the pressure should be backward and a little upward; in umbilical hernia it should be backward; in oblique inguinal hernia it should be upward, outward, and backward; in femoral hernia it should be downward until the hernia enters the saphenous opening, and then "backward toward the pubic spine" (MacCormac). If the bowel is reduced, it passes from the hand with a sudden slip and enters the belly with an audible gurgle; omentum, when reduced, slowly glides back without gurgling. Taxis is never to be continued long, and it is not even to be attempted in cases of great acuteness, in cases where strangulation has lasted for several days, in cases known to have been previously irreducible, in cases associated with stercoraceous vomiting, or in inflamed or gangrenous herniæ.

If taxis fails, obtain the patient's permission to operate. Anesthetize; try taxis again while ether is being dropped upon the hernia to cause cold; if reduction fails, at once perform herniotomy. Taxis possesses certain dangers: It may rupture the bowel; it may rupture the neck of the sac and force the bowel through the rent; it may strip the peritoneum from around the hernial orifice and force the bowel between the detached peritoneum and the abdominal wall; it may reduce a hernia into the belly when the bowel is still strangulated by adhesions; it may reduce the hernia *en masse* or *en bloc*, the sac and strictured bowel being forced together through the internal ring. By reduction *en bissac* is meant the forcing of a congenital hernia into a congenital pouch or diverticulum. In any of the above accidents strangulation may persist after apparent reduction by taxis, and this condition calls for instant laparotomy—in most instances through the hernial aperture. If taxis is successful, put the patient to bed, apply a pad and bandage, allow no food until vomiting ceases, merely permit him to take a little hot water, for twenty-four hours, and keep him on a liquid diet for several days. At the end of the first week give solid food. Do not disturb the bowels for a few days, but if they have not acted when four or five days have elapsed since the operation, give a saline cathartic and an enema.

Herniotomy.—If there has been stercoraceous vomiting, the stomach must be washed out before giving the anesthetic, and during the administration of the anesthetic the head should be turned upon its side. In most cases a general anesthetic can be given, but in some desperate cases it is not justifiable to give ether or chloroform, and a local anesthetic must be used (eucain, cocain, or Schleich's fluid). Wrap the patient up in blankets. In most cases try gentle taxis for a brief time after the patient has been anesthetized, and while ether is being dropped upon the hernia to cause cold. Never try taxis if stercoraceous vomiting has occurred. If taxis fails, at once sterilize the parts and operate. The instruments required in herniotomy are a scalpel, a hernia knife (Fig. 592) and director (Fig. 560, B), hemostatic and dissecting forceps, retractors, scissors, a dry dissector, partly curved needle, a needle-holder, and Murphy buttons. Drainage-tubes should be ready. During the *operation* the patient lies upon his back with the shoulders raised, the surgeon standing to the patient's right side. In *oblique inguinal hernia* it has been the custom since the days of Scultetus to raise a fold of skin at a right angle to the axis of the external ring and transfix it, the wound which results being extended until it becomes three inches in length. This incision possesses no special merit. It is better to cut from without inward, and to make the same incision as for the performance of a radical cure in a non-strangulated case. The superficial tissues are divided until the sac is reached, and no special attempt is made to identify them. The sac must be identified, and it is known by the fat which usually covers it, by the arborescent arrangement of its vessels, by the fact that it can be pinched up between the finger and thumb, and the layers rolled over each other, and by the fluid within the sac. Should the sac be opened? In very recent cases it may not be actually necessary, but if there is any doubt as to the condition of the bowel, or if a radical cure is to be attempted, open the sac and be certain as to the condition of its contents. As there is always

Fig. 592. — Cooper's curved herniotome.

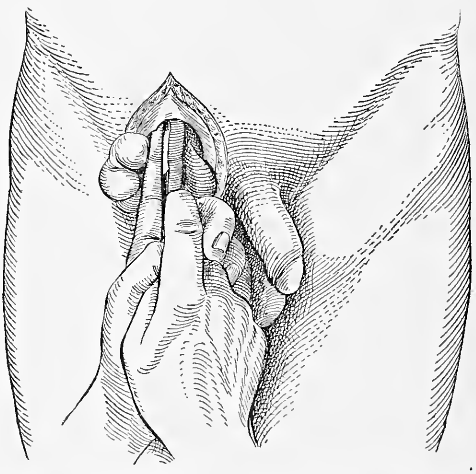


Fig. 593.—The division of the constriction from within outward (Sultan).

some doubt as to the condition of the contents, and as a radical cure is to be made, make it a rule to open the sac. The sac is opened and the contents examined for fecal odor (which is not unusual) and for gangrenous smell; the thickness of the bowel is estimated, and the color and luster are determined. The constriction is nicked with a hernia knife. In oblique inguinal hernia nick the constriction upward and outward or directly upward as shown in Fig. 593. In direct inguinal hernia the cut is made upward and inward. Always pull the bowel down and examine the seat of constriction to see what damage has been inflicted at that point. If the bowel glistens; if the proper color comes back after irrigation with very hot water; and if there are no spots of gangrene, restore the bowel to the abdomen and do a radical cure. If the bowel is in a doubtful condition, fasten it to the incision, apply a dressing, and watch the development of events. If the bowel is gangrenous, our action depends upon the condition of the patient. If the patient is in good condition, resect the gangrenous portion, and perform end-to-end anastomosis by means of a Murphy button. If the patient's condition is bad, make an artificial anus, and at a later period perform anastomosis. An artificial anus can be made by the method of Bodine (page 964). Unfortunately in these cases the artificial anus must usually be made in the small intestine. In most cases in which it seems necessary to make an artificial anus prepare the bowel for the opening, but do not open at once, because the bowel may recover in a day or two, when it can be restored to the belly; or it may slough and form an artificial anus. In such doubtful cases fasten the bowel to the belly-wall with sutures, dust it with iodoform, dress it with hot antiseptic fomentations, and await future developments. Gangrenous omentum requires ligation and resection. If the bowel is fit to reduce, push it just inside the ring, irrigate the parts, suture, and perform a radical cure. In *femoral hernia* we can make the incision one inch internal to, and parallel with, the femoral vessels, and crossing the tumor and ligament (Barker); but it is better to make the incision of Fabricius for radical cure. Divide the constriction by cutting upward and a little inward. In *umbilical hernia* make a slightly curved incision a little to one side of the middle of the tumor, open the sac, separate adhesions, and divide the constriction by cutting upward or downward, and sometimes also laterally.

After an operation for strangulated hernia put the patient to bed; bend the knees over a pillow; give no food by the mouth for thirty-six hours (MacCormac), only allowing hot water, and give an enema of salt solution containing brandy every sixth hour. Abdominal pain and tenderness call for the administration of saline cathartics and enemata containing turpentine or oil of rue. The enema rutæ is a favorite preparation in St. George's Hospital, London. It is made as follows: Take sixteen ounces of an infusion of camomile, warm it, and pour it upon ℥iij of confection of senna (Sheild). If there are no abdominal pain and tenderness, the bowels need not be disturbed for a few days; but if at the end of four or five days they have not acted, give a saline cathartic and an enema. At the end of about three weeks get the patient up. If a radical cure has not been attempted, apply a pad and a spica bandage to the groin, and later a truss. A truss should not be worn if a radical cure has been made.

Mortality.—Cases of strangulated hernia irreducible by taxis will prac-

tically all die without operation. The mortality following operation is large; it is not due to operation, but is due to the condition, and is due particularly to delay in operating or to forcible antecedent taxis. Sultan, from a total of

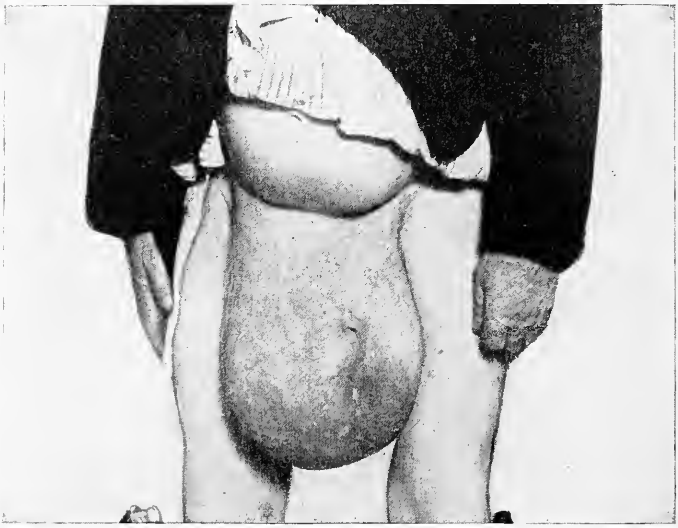


Fig. 594.—Double inguinal rupture (Horwitz).

1429 herniotomies, estimates the mortality at 20.7 per cent. Estimating the mortality according to the time of strangulation, Henggeler reaches the following conclusions: The mortality of cases operated upon "the first day-after the strangulation is 8.09 per cent.; during the second day, 22.2 per cent.; during the third day, 45.5 per cent.; during the fourth day, 60 per cent." ("Atlas and Epitome of Abdominal Hernias," by Dr. George Sultan. Translated and edited by Wm. B. Coley, M.D.).

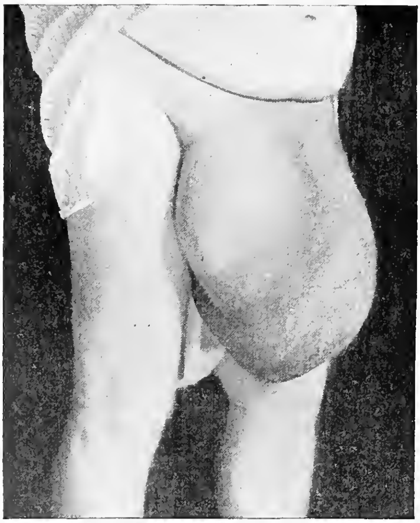


Fig. 595.—Double inguinal rupture (Horwitz).

Hernia in Childhood.—Hernia is extremely common in children, but it is an interesting fact that if one conducts a careful investigation of hernia in adults, it will be found that but 5 or 6 per cent. of them have suffered with the hernia in childhood. This fact seems to demonstrate positively that the majority of cases of hernia in childhood are recovered from. A. J. Ochsner ("Jour. Amer. Med. Assoc.," Dec. 22, 1900), in commenting upon the frequency of hernia in childhood, alludes to Malgaigne's statistics. Malgaigne

estimated that during the first year of life one child in every twenty-one has hernia, and that this proportion is maintained until the age of six. Then it diminishes rapidly until the age of thirteen, at which age there is one hernia in every seventy-seven children. It is, therefore, obvious that 75 per cent. of all herniæ in children of six years will heal spontaneously before the age of thirteen. Ochsner states that 95 per cent. of herniæ in children will be cured without operation. He points out that between the ages of thirteen and twenty hernia is fairly common among boys, but very rare among girls. The reason for this tendency to cure is somewhat uncertain. The view advocated by Thomas C. Martin is that, as the pelvis broadens, the parietal peritoneum enlarges. It does this at the expense of the mesentery, which is shortened, and the internal abdominal ring is displaced. In a very instructive analysis of this condition Ochsner shows that in 25 per cent. of cases of hernia in childhood hereditary weakness exists; that the condition is commoner among the poorer classes than among the richer; that in many cases there is an undescended testicle; and that the chief cause is an excess of intra-abdominal pressure. This excess of intra-abdominal pressure may result from flatulent distention of the stomach and intestines, the product of bad feeding; constipation and straining; straining on urinating, due to the existence of phimosis; vomiting, or cough. He thinks that, as a rule, indigestion causes flatulence and pain; that the child cries; that this increases the pressure; that the mother then feeds it, in order to keep it quiet; and that this makes it worse.

Treatment.—Strangulated herniæ, irreducible herniæ, herniæ with very large rings, cases in which trusses fail, and cases associated with reducible hydrocele require operation (Ochsner). Most cases are curable without operation, the ring being guarded by a truss of rubber or a pad of lamb's wool. Ochsner believes that many cases can be cured by keeping the child recumbent, with the foot of the bed raised, from four to six weeks. If phimosis exists, it should be operated upon, and any other causative condition should be treated (cough, vomiting, constipation, flatulent indigestion, etc.). An umbilical hernia can usually be cured by the use of a cork. The cork should be one inch in diameter and one and one-fourth inches in length, and shaped like a cone. The smaller end is pushed into the ring and the cork is held in place by adhesive plaster. In two weeks a smaller cork must be used, and in six or eight weeks it can usually be dispensed with. Radical cure operations are seldom done before the age of four (page 976).

Varieties of Hernia.—In *direct inguinal hernia* the bowel passes out through Hesselbach's triangle internal to the deep epigastric artery. It enters the inguinal canal low down, and passes outside the conjoined tendon or forces the conjoined tendon before it or splits through the tendon. The neck of the sac is internal to the deep epigastric artery. The coverings of this hernia, when it passes external to the conjoined tendon, are the same as those of an indirect inguinal hernia, except that the transversalis fascia instead of the infundibuliform process of the transversalis fascia is one of the layers. When a direct hernia pushes before it the conjoined tendon, its coverings are skin, superficial fascia, intercolumnar fascia, conjoined tendon, transversalis fascia, subserous tissue, and peritoneum.

In *indirect inguinal hernia* the bowel passes through the internal abdominal ring external to Hesselbach's triangle and external to the deep

epigastric artery. It passes down the inguinal canal and emerges from the external ring; it may enter the scrotum or labium (*scrotal* or *labial hernia*), or it may not. The neck of the sac is external to the deep epigastric artery. Its coverings are skin, superficial fascia, intercolumnar fascia, cremaster muscle, infundibuliform fascia, subserous tissue, and peritoneum.

Congenital inguinal hernia is a portion of bowel within an unclosed vaginal process. The bowel in congenital hernia has one layer of peritoneum in front of it. The testicle is posterior and below (Fig. 596). Always remember that bowel may not enter the sac of a congenital hernia for several months after birth. Congenital hernia conceals or buries the testicle; acquired hernia does not. If a vaginal process, open above and closed below, contains a hernia, the condition is called *hernia into the funicular process*.

If the funicular process is closed at the abdominal end but not below, a hernia in a special sacmay descend back of the vaginal tunic. This condition is known as *infantile hernia*. In infantile hernia there are three layers of peritoneum in front of the bowel—the two layers of the vaginal tunic and the one layer of sac. The testicle is in front (Fig. 597).

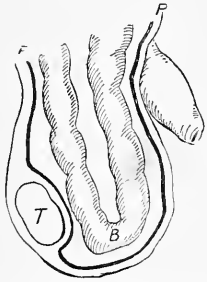


Fig. 596.—Congenital hernia: *T*, Testicle; *F*, *P*, funicular process; *B*, bowel.

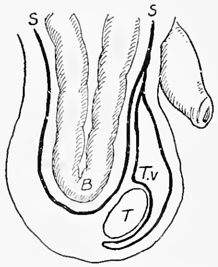


Fig. 597.—Infantile hernia: *T*, Testicle; *T.v.*, tunica vaginalis; *S*, *S*, sac; *B*, bowel.

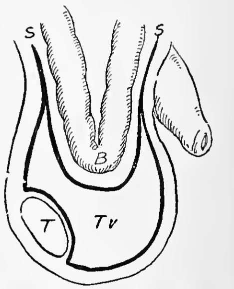


Fig. 598.—Encysted infantile hernia; *T*, Testicle; *T.v.*, tunica vaginalis (represented as distended); *S*, *S*, sac; *B*, bowel.

If the tunica vaginalis is closed above and not below, and a hernia pushes down the vaginal process and causes it to double on itself, the condition is known as *encysted infantile hernia* (Fig. 598).

In *femoral hernia* the bowel descends along the femoral canal, and the neck of the sac is at the femoral ring. The neck of a femoral rupture is always external to the pubic spine; the neck of an inguinal rupture is always internal to the pubic spine. Femoral hernia is never congenital. Its coverings are skin, superficial fascia, cribriform fascia, crural sheath, septum crurale, subserous tissue, and peritoneum.

Umbilical hernia may be congenital (the ventral plates having closed incompletely), infantile (the cicatrix of the umbilicus having stretched), or acquired.

Ventral hernia is a protrusion through any part of the anterior abdominal wall except at the umbilical or inguinal regions. A ventral hernia may be median (*hernia of the linea alba*) or lateral. The treatment is radical operation.

Epigastric hernia is a form of ventral hernia. In this condition there is a protrusion of the peritoneum in the space bounded by the ensiform cartilage,

the ribs, and the umbilicus. The sac of peritoneum may be empty, may contain omentum, or omentum and bowel. The stomach very rarely passes into the sac. The protrusion is usually, but not invariably, through the linea alba.

Cecal hernia is very uncommon in women. Most cecal herniæ are preceded and caused by hernia of the small gut. Usually there is a complete sac, but sometimes the sac is partial. The appendix may be in the sac. If the sac is incomplete, it means that we have one of the 18 per cent. of cases in which the cecum is not completely covered with peritoneum. A cecal hernia may be and usually is right inguinal, but may be right femoral, left inguinal, or left femoral.

Hernia of the appendix may occur alone, and Merigot de Treigney collected 22 cases of it ("Thèse de Paris," 1887). In 17 the hernia was inguinal; in 5 it was femoral. I operated upon a case of appendicitis in which the inflamed appendix was the sole contents of an incomplete right inguinal hernia sac.

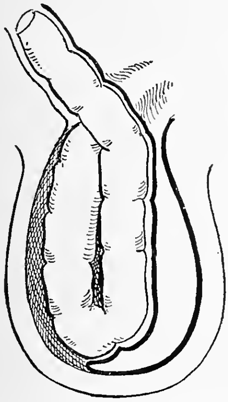


Fig. 599.—The large intestine behind the peritoneum (Weir).

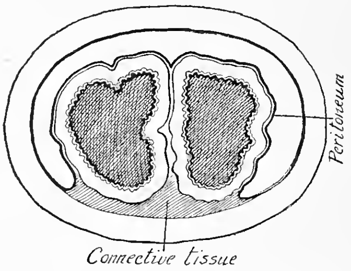


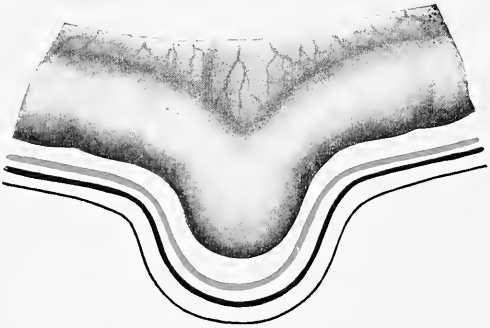
Fig. 600.—The retroperitoneal large intestine in a cross-section of the hernia with its incomplete sac (Weir).

Sliding hernia of the ascending colon is due to the looseness of the peritoneum of the iliac region, which permits a portion of the large bowel to slide into a hernia. In such a case the posterolateral aspect of the sac is absent (Figs. 599 and 600). The descending bowel carries with it into the scrotum a fold of loosened peritoneum, just as in the descent of the testis (see Weir, in "Med. Record," Feb. 24, 1900). Sliding hernia of the ascending colon is wrongly called sliding hernia of the cecum. *Sliding hernia of the descending colon*, wrongly called sliding hernia of the sigmoid, may occur.

In *properitoneal hernia* the sac is between the peritoneum and transversalis fascia. This form of hernia is sometimes produced by making taxis on an inguinal hernia, when the internal ring is small or is blocked by an undescended testicle. In properitoneal inguinal hernia, which is the most common form, there are two sacs detectable, one in the scrotum, the other parallel with Poupart's ligament, and as one sac is emptied, the other distends (Breiter, of Zürich).

In *interstitial inguinal hernia* the hernia sac is between the transversalis muscle and fascia, or between the external and internal oblique muscles, or between the fibers of the internal oblique muscle, or between the external oblique muscle and the transversalis fascia, the internal oblique and transversalis muscles being pushed aside (Sultan's "Atlas of Abdominal Hernias").

In *superficial inguinal hernia* the sac is between the aponeurosis of the external oblique muscle and the superficial fascia. This variety of hernia is always congenital and the testicle is invariably misplaced.



A.

B.

Fig. 601.—A. Diagrammatic representation of Richter's hernia of the intestinal wall. B. Diagrammatic representation of a hernia of Meckel's diverticulum (Sultan).

Obturator hernia passes through the obturator membrane or the obturator canal, and is felt below the horizontal ramus of the pubes, internal to the femoral vessels.

Lumbar hernia occurs at the edge of or through the quadratus lumborum muscle.

Sciatic or *gluteal hernia* passes through the great sacrosciatic foramen, above or below the pyriformis muscle, or through the lesser sacrosciatic foramen.

Pudendal hernia protrudes into the lower part of the labium, the bowel having descended between the ischial ramus and the vagina.

Perineal hernia presents in the perineum, between the rectum and the prostate gland or between the rectum and the vagina.

Internal, retroperitoneal, or *intra-abdominal herniæ* include hernia into the *foramen of Winslow*, hernia into the *retroduodenal fossæ*, the *retrocecal fossæ*, and the *intersigmoid fossa*.

Vaginal hernia is associated with uterine prolapse or ensues upon destruction of the vaginal wall.

Richter's hernia is the catching of a portion of the circumference of the bowel. It is also called *partial enterocele* or hernia of the *intestinal wall*. Strangulation of a partial enterocele does not produce stercoraceous vomiting

or absolute constipation, and the protrusion is barely perceptible or cannot be palpated.

Littré's hernia is hernia of Meckel's diverticulum (Fig. 601, B). This diverticulum is the persistent vitelline duct and comes off from the ileum from 12 to 36 inches above the ileocecal valve. It arises from the convex side of the gut and rarely has a mesentery (pp. 342 and 840).

Rokitansky's diverticular herniæ are due to separation of the muscular fibers of the bowel, permitting the sacculation of mucous membrane and peritoneum. These false diverticula may be no larger than peas or may be larger than walnuts, and there may be scores of them in one patient. They may produce no symptoms, or may lead to peritonitis or to symptoms of intestinal obstruction.

Hernia of the Bladder.—This is a protrusion of a portion of the bladder-wall through a hernial opening. The protrusion may or may not be covered with peritoneum.* It is most frequently met with in the inguinal region. Brunner describes three forms: (1) Entirely without a peritoneal covering (extraperitoneal); (2) partly covered with peritoneum (paraperitoneal—the commonest form); (3) completely covered with peritoneum (intraperitoneal). The bladder may constitute the hernia, or there may be an ordinary hernia and also a cystocele. In an inguinal hernia the bladder will be internal and somewhat behind the other constituent parts of the protrusion. Hernia of the bladder is much more common in men than in women.

A hernia of the bladder may become strangulated. In some cases a diagnosis of hernia of the bladder can be made by the fact that the protrusion lessens in size when the patient micturates and increases in size as urine gathers, or when the bladder is injected with fluid. The treatment should be operative. When the bladder is exposed, it is replaced with or without resection of a portion.

Diaphragmatic Hernia.—The majority of cases are congenital, and in 90 per cent. of them there is no sac. The hernia may pass through a natural opening or through a gap due to congenital defect. The hernia is most common on the left side, and the stomach is the organ usually displaced. When the stomach passes suddenly through the left side of the diaphragm, there will be dyspnea, cyanosis, displacement of the heart to the right, pain in the upper abdomen, thirst, and in most cases rapid death. When the stomach has entered the left side of the thorax, there is a tympanitic note on percussing the thorax, the heart is displaced to the right, and the side of the chest is unduly prominent. In 250 cases of traumatic diaphragmatic hernia collected by Leichtenstern the diagnosis was made before death in but 5 cases. Strangulation of a diaphragmatic hernia produces severe pain in the upper abdomen, violent vomiting, constipation, boat-shaped abdomen, great thirst, rapid wasting, and the excretion of a very small amount of urea (Mackenzie and Battle, "Lancet," Dec. 7, 1901).

Treatment.—Open the belly for exploration. If hernia is found, return it to abdomen; open the chest and suture the diaphragm. Mackenzie and Battle, Mikulicz, Humbert, and others have operated for this condition.

Hernia of the Ovary.—The ovary, because of failure of descent, may remain in the lumbar region. It may pass into the inguinal canal or labium

* Brunner, in Deutsch. Zeitschr. f. Chir., 1898, vol. xlvii.

majus (inguinal hernia); to the gluteal region (gluteal hernia); to the region of the obturator foramen (obturator hernia); or to the front of the abdomen (ventral hernia). In congenital inguinal hernia there may be ovary alone, or ovary, tube, omentum, and even part of a bicornate uterus (Garrigues). It is impossible to restore a congenital hernia. Acquired hernia may follow a fall and sometimes it can be restored. A femoral or crural ovarian hernia, a condition in which the ovary passes to the front of the thigh below Poupart's ligament, is never congenital. In some cases a herniated ovary can be returned within the abdomen. Any herniated ovary may inflame.

Treatment.—If it can be restored, a truss will probably retain it. If it cannot be restored or if it is painful or undesirable to wear a truss, operate. Expose the ovary, return it to the belly if healthy, and do a radical cure of the hernia. In some conditions of disease remove the ovary.

Hernia of the Uterus.—This condition is a surgical curiosity, but a few cases have been reported (see John Howard Jopson's case in "Annals of Surgery," July, 1904). The hernia may be umbilical, ventral, inguinal, or femoral. Hernia of the unimpregnated womb may be congenital or acquired; impregnation may occur when the uterus is herniated, or an impregnated uterus may pass into a preëxisting hernia sac. If a herniated uterus becomes impregnated or if an impregnated uterus becomes herniated, pregnancy may go on to term. Multiple pregnancies predispose to uterine hernia. Ovarian hernia may precede uterine hernia, or hernia of omentum adherent to the uterus may pull that organ into the sac. In many cases congenital anomalies have been found to exist (bicornate uterus, rudimentery uterus, shortness of the round ligament, imperforate vagina, etc.). A hernia of the uterus enlarges and becomes painful during menstruation, and a vaginal examination shows that the uterus is absent from its normal position and that the direction of the cervix and vagina are abnormal (Jopson). A uterine sound cannot be passed at all or can be passed with great difficulty. The hernia is hard and probably pyriform. If impregnation occurs, there are the ordinary signs of pregnancy and progressive enlargement of the hernia.

Treatment.—Expose the mass by incision. If conditions justify such a course, return the uterus and adnexa, if they are present (one or both ovaries and tubes may be present), to the abdomen and do a radical cure. If the uterus is infected, remove it. Jopson in his case removed the uterus and right ovary and fastened the uterine stump into the wound.

XXVIII. DISEASES AND INJURIES OF THE RECTUM AND ANUS.

Examination of the Anus and Rectum.—Whenever possible, have the bowels emptied before an examination by the administration of a cathartic and the use of an enema.

Place the patient on the left side, with the knees drawn up and the pelvis elevated (the *left-lateral-prone position of Sims*). The anus is carefully inspected, the anal folds being opened during the process. By inspection the surgeon can notice the external opening of a fistula, external piles, protruding internal piles, mixed piles, pruritus, discharge from the rectum, eczema, fissure, tumor, ulcer, condylomata, or abscess.

Next, a digital examination of the rectum is made. The nail of the index-finger is filled with soap and the finger is oiled, or, better, is covered with a rubber finger-tip which is oiled. The digit is gently inserted through the sphincter, the patient being asked to strain lightly while it is passing. A digital examination enables the surgeon to detect an ulcer, a polypus, a tumor, a stricture, and to determine certain points regarding the condition of the prostate in the male and the uterus in the female.

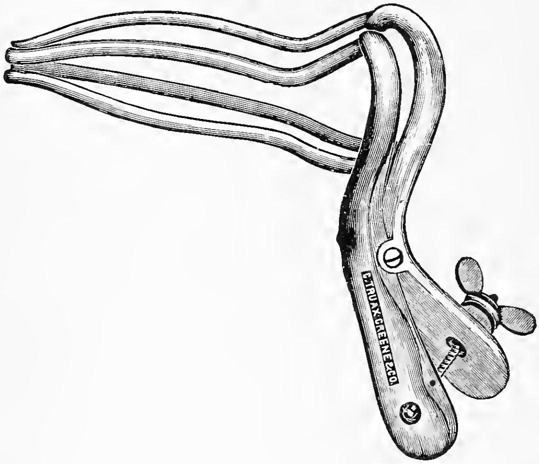


Fig. 602.—Mathews' self-retaining rectal speculum.

Next, in some cases the rectum must be examined with a speculum. It is not often necessary to give ether. Mathews' speculum (Fig. 602) is very serviceable. Sims' duck-bill speculum is a valuable instrument. The speculum is warmed, oiled, and slowly introduced. It is first directed toward the umbilicus, and when it passes the sphincter, its direction is gradually altered until it is toward the promontory of the sacrum. Illumination is obtained by direct sunlight, or by a forehead mirror and an electric light. This ex-

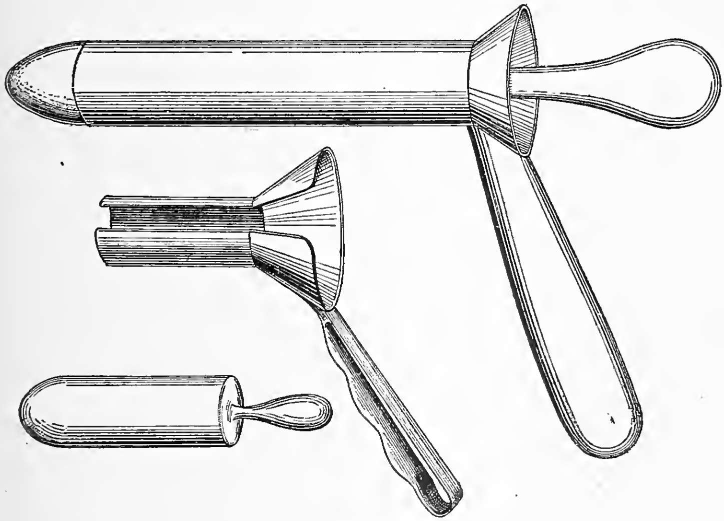


Fig. 603.—Kelly's rectal specula.

amination will extend, confirm, or disprove the findings of the digital examination; ulcers, hemorrhoids, and malignant growths can be carefully examined, and the condition of the rectal mucous membrane can be thoroughly investigated.

Marion Sims in 1845 demonstrated the ballooning of the vagina by atmospheric pressure, and in 1870 Van Buren applied this method to the rectum. Kelly in 1895 put forth his straight tubes and described in detail the methods and advantages of examination by them, and the great diagnostic value of ballooning the rectum. Kelly's method of examination is shown in Fig. 604. The tubes are shown in Fig. 603. It is not necessary to give ether. The patient is placed in the knee-chest position. A tube containing an

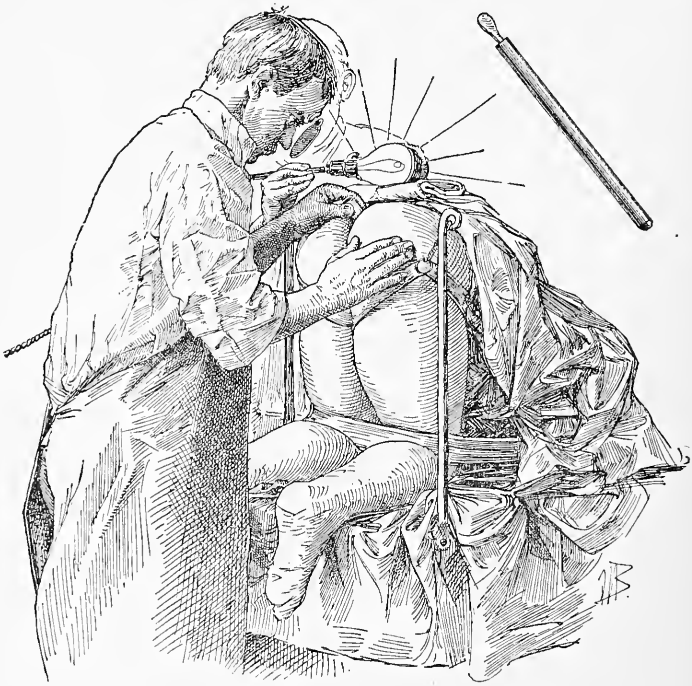


Fig. 604.—Examination of the rectum by reflected light (Kelly).

obturator is well greased with vaselin. "The buttocks are drawn apart, and the blunt end of the obturator is laid on the anus, which is also coated with vaselin. The direction of the instrument should be first downward and forward, and, when the sphincter is well passed, up under the sacral promontory. The moment the speculum clears the sphincter ani and the obturator is withdrawn, air rushes in audibly and distends the bowel." The bowel being distended with air, the mucous membrane is plainly seen as the tube is slowly withdrawn and the light is reflected into the speculum. The Kelly tube must be used with great care, as harm may be done by it, and the longest tube should be used only in exceptional cases.

I use with the greatest satisfaction Tuttle's pneumatic proctoscope (Fig.

605). Dr. Tuttle describes it as follows ("Diseases of the Anus, Rectum, and Colon," by James P. Tuttle): "This instrument is composed of a large cylinder (*f*), into one part of the circumference of which is fitted a small metallic tube closed by a flint-glass bulb at its distal end. The electric lamp (*d*) is fitted upon a long metallic stem, and carried through the small cylinder to the end of the instrument, as shown in the illustration. The proctoscope is introduced through the anus with the obturator (*a*) in position. As soon as the internal sphincter is passed, this obturator is withdrawn and the bayonet-fitting plug (*b*), which contains either a plain glass window or a lens focused to the length of the instrument to be used, is inserted in the proximal end of the instrument. This plug is ground to fit air-tight and thus closes the instrument perfectly. The plug being inserted in the tube, a very slight pressure upon the hand-bulb will cause inflation of the rectal ampulla to such an extent that the whole rectum can be observed and the instrument can be carried up to the promontory of the sacrum without coming in contact with the rectal wall. Further dilatation will show the direction of the canal leading into the sigmoid, and, by a little care in manipulating the instrument and keeping the gut well dilated in advance, it can be carried up into this portion of the intestine without the least traumatism of the parts. If any fecal matter obscures the light by being massed or smeared over the glass bulb, the plug can be removed, and a pledget of cotton, introduced with a long dressing forceps, will wipe this off so that the plug can be reintroduced and the examination continued with very slight delay or inconvenience. The adjustable handle (*c*) fits on the rim of the instrument and thus converts it into a Kelly tube. This instrument is operated with an ordinary dry battery of four cells. It is better, however, to have a battery with six cells, as it will not require being recharged so frequently."

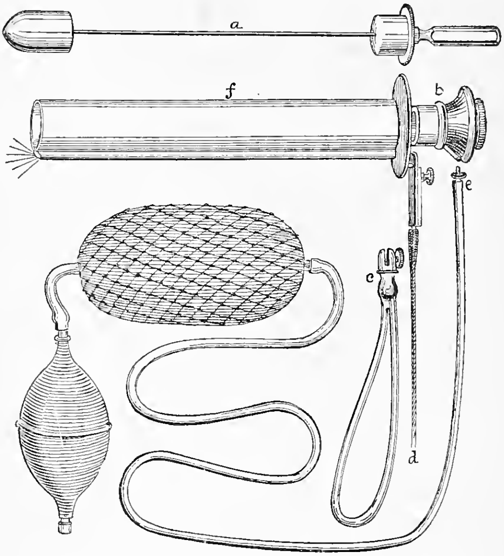
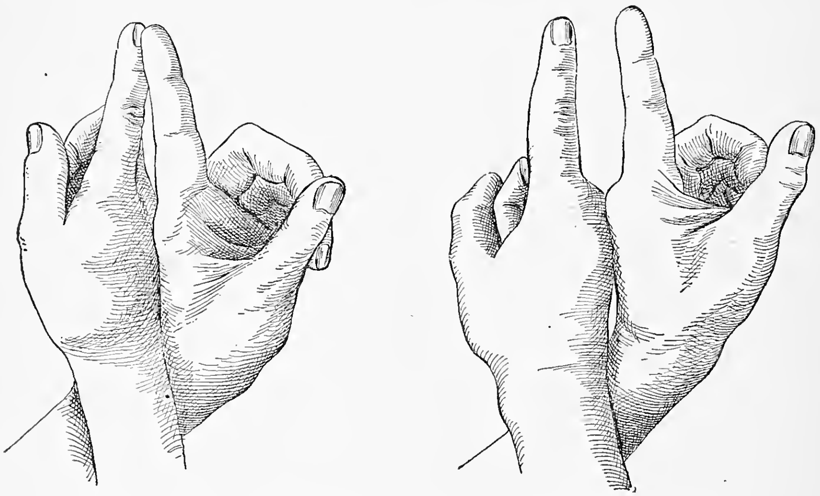


Fig. 605.—Tuttle's pneumatic proctoscope: *a*, Obturator; *b*, plug with glass window closing end of tube; *c*, handle; *d*, cords connecting instrument with battery; *e*, inflating apparatus; *f*, main tube of proctoscope.

If a patient is placed in the knee-chest position and anesthetized, the sphincter can be stretched by the fingers, and the rectum will distend with air and can be easily examined. The fingers are introduced as suggested by Martin (Fig. 606), and the rectum becomes visible when they are separated (Fig. 607).

Foreign Bodies in the Rectum.—It is not at all unusual for hard,

undigested articles taken with the food to lodge in the rectum. They can usually be removed through a speculum by means of forceps. In some cases ether must be given and the sphincter stretched; in others, the sphincter must be divided. Sometimes large bodies are voluntarily inserted and the individual is unable to remove them. Lewis H. Adler ("Am. Med.," July 20, 1901) removed the valve of a steam radiator pipe from the rectum. The small end was one and one-half inches in diameter; the large end was two and one-half inches in diameter. The patient had been in the habit of introducing it frequently and removing it with a hook of galvanized iron wire. Marmaduke Shield ("Lancet," Oct. 12, 1901) reports the case of a man of sixty years of age who forced a gallipot into the rectum. The pot was two and one-half inches in diameter and two and three-fourth inches in height. The patient broke it trying to get it out. Shield incised the rectum from behind and removed the article by means of obstetric forceps.



Figs. 606, 607.—A new and simple method of proctoscopy (Thomas C. Martin).

A remarkable series of similar cases will be found in "Anomalies and Curiosities of Medicine," by Geo. M. Gould and Walter L. Pyle.

Wounds of the rectum require free drainage, irrigation, and antiseptic dressing. If the peritoneum is opened, laparotomy must be performed, the peritoneal cavity irrigated, the rectal wound sutured, and the abdomen drained.

Ischiorectal abscesses are situated in the ischiorectal fossa. They travel in the line of least resistance, which is upward, and more often burst into the bowel than externally. They may follow chilling of the region or external traumatisms, may be caused by perforations of the rectum by hard fecal masses, or by the direct passage of bacteria into the fossa through a fissure, an ulcer, or an ulcerated pile. They may be either acute or tuberculous. In many cases the process is at first tuberculous, and secondary infection with pyogenic bacteria takes place.

The **symptoms** are the same as those of abscess anywhere, the swelling, however, being brawny and fluctuation being hard to detect. Pain in the groins is often complained of, and there may be enlarged glands in these regions. Abscesses commonly result in fistula, and a patient should be warned of this tendency before operation is performed.

The **treatment** is instant incision, the cut radiating from the anus like the spoke of a wheel. Incision is followed by insertion of a finger, breaking down the necrotic septa of cellular tissue, irrigation and packing with iodoform gauze, or the insertion of a drainage-tube. If a fistula is found to open in the rectum, it is operated upon as directed in the article upon Fistula.

Imperforate Anus.—There are two forms of this condition. In one form the rectum empties into the bladder, vagina, or urethra. In the other form there is no rectal opening either upon the surface of the body or in the urinary organs. The diagnosis is usually at once apparent, except in cases where the anus looks normal, when the diagnosis will often not be made until symptoms of obstruction arise.

Treatment.—If the rectum bulges when the child cries, open into it with a knife and keep the opening patent by inserting a plug of iodoform gauze. In cases in which the rectum is more deeply seated, a catheter is introduced into the bladder, an incision is made from the anus to the coccyx, the rectum is sought for, and when found, is sewed to the anus and is incised. In some

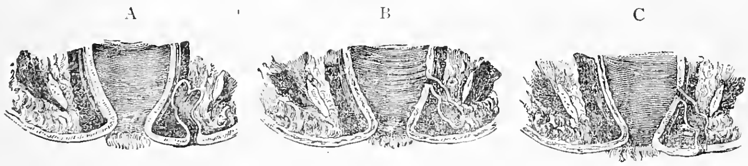


Fig. 608.—Fistula in ano: A, Blind external; B, blind internal; C, complete (Esmarch and Kowalzig).

cases Keen and others have performed Kraske's sacral resection, pulling down the rectum to the anal margin, sewing it there, and incising the occluded anus. If the rectum cannot be found or cannot be pulled down, an artificial anus must be made.

Fistula in ano is the track of an unhealed abscess. An abscess in the anal region is apt to refuse to heal because of the constant movement of the parts (produced by respiration, coughing, the passage of gas, defecation, etc.). The passage of feces will keep a fistula open. If a tuberculous ulcer perforates, a tuberculous sinus forms, and a tuberculous sinus is also apt to follow a cold abscess of the ischiorectal fossa. Fistula is often associated with phthisis pulmonalis, and is not unusually linked with piles, cancer, or stricture.

There are three varieties of fistula—the blind external (Fig. 608, A), the blind internal (Fig. 608, B), and the complete (Fig. 608, C). The *external* opening is usually near the anus, but may be far away, and there may be only one pathway or there may be several sinuses and openings. In a healthy individual the external orifice is small and a mass of granulations sprouts from it. In a tuberculous fistula the external orifice is large and irregular, with thin and undermined edges, shows no granulations, extrudes small quantities of sanious pus, and the skin about it is purple and congested. In a fistula following an anal abscess the *internal* opening is just above the anus,

between the two sphincters. In fistula following an ischiorectal abscess the internal opening is usually near the anus, but may in rare cases be above the internal sphincter. A sinus may run up under the mucous membrane from the internal opening. In a *horseshoe fistula* the internal opening is usually upon the posterior wall of the bowel, "and from this a tract leads into the ischiorectal fossa, not on one side only, but upon both. Therefore we have one opening into the bowel and one through the skin on either side."* In some cases of horseshoe fistula there is no internal opening; in other cases there are two openings. In an old fistula the track becomes fibrous and cannot collapse. Two or more fistulæ may exist in the same patient. In dealing with a fistula always determine if the condition is stationary or progressive. The **symptoms** of a complete fistula are the passage of feces and gas through the opening and the flow of a discharge which stains the clothing. In a complete fistula a probe can be carried from the external opening into the bowel. After a time incontinence of feces is apt to come on, repeated attacks of inflammation thickening the rectum and destroying its sensibility. From time to time the opening will block, and new abscesses form. In examining a fistula use Brodie's probe, as its flat handle enables one to locate the direction the bent instrument has taken, and its slender shaft will find its way through a very small channel.

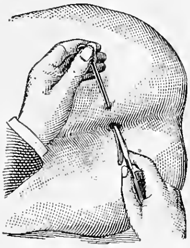


Fig. 609.—Operation for fistula in ano (Esmarch and Kowalzig).

Treatment.—In treating a fistula cleanse the parts, as cleanly work, though it will not prevent pus, will limit suppuration. The external parts are washed with soap and water. The rectum, which must be empty, is irrigated with hot saline solution. Corrosive sublimate should not be used in the rectum, because it is irritant, causes a flow of serum, and hence lessens tissue resistance, and is rendered inert as an antiseptic by being converted into sulphid of mercury. Anesthetize the patient. If operating upon a complete fistula, pass a grooved director into the external opening, carry it through the sinus, make it enter the bowel, bring its point out externally, and lift the tissue between the sinus and the surface. Incise the bridge of tissue (Fig. 609). Cut the sphincter at a right angle to its fibers, and do not cut it more than once at one operation. Push the finger to the depth of the wound, to determine that the sinus does not ascend above the internal opening. If there are two fistulæ, cut one through, and when one wound has healed, cut the other. In some straight sinuses the tract can be extirpated and the parts sutured, primary union occasionally resulting. Search with a small probe for branching sinuses, and if any are found, slit them open. Examine carefully to see if there is a sinus beneath the mucous membrane of the bowel, and if such a sinus is found, slit it up. Curet all sinuses, and if they are very fibrous, clip them away with scissors. Cut away diseased skin; irrigate with salt solution; pack with iodoform gauze; and dress with gauze and a T-bandage. In forty-eight hours remove the dressings, spray with peroxid of hydrogen and irrigate with salt solution, dust with iodoform, insert lightly to the depths of the wound a piece of iodoform gauze, and reapply the dressings. Dress the wound thus every day until healing is almost complete. It is unnecessary to

* "Diseases of the Rectum, Anus, and Sigmoid Flexure," by Joseph M. Mathews.

confine the bowels beyond forty-eight hours, at which period, if they have not moved, an enema is given. If the dressing at any time becomes stained with feces, redress at once. Get a tuberculous patient out of bed as soon as possible.

If a blind external fistula does not heal, every sinus must be incised, and thickened walls must be cut away or scraped away.

In a blind internal fistula an external incision is made to convert the case into a complete fistula, which is then treated as is directed above.

In horseshoe fistula, more than one operation may be necessary in order to avoid cutting the sphincter muscle twice in one operation, a proceeding which would probably lead to fecal incontinence. One side alone is operated on at one séance. Sinuses are opened and scraped, the sphincter is divided, the angles and edges of skin are trimmed away, and the wound is packed. When the wound is healed, or nearly healed, the other side should be operated upon.

If fecal incontinence results from an operation for fistula, remove the scar tissue and endeavor to suture the separated muscular fibers. Should an operation be undertaken for fistula if phthisis exists? Many of the old masters said *no*. Mathews sums up the modern view: in incipient phthisis operate; in rapidly progressive fistula operate whether cough exists or not; if much cough exists, do not operate unless the fistula is rapidly progressive; in the last stages of phthisis do not operate.

Pruritus of the anus is a symptom, and not a disease. It may be due to piles, fissure, seat-worms, eczema, nerve-disturbance, kidney disease, gout, jaundice, constipation, inebriety, the opium-habit, torpid liver, dyspepsia, alcohol, tea-drinking, vesical calculus, tobacco-smoking, urethral stricture, uterine disease, diabetes, ovarian trouble, and mental disorder. In some cases it seems to be a pure neurosis and no special causative factor can be recognized. It is vastly more frequent in males than in females, and is especially common in fat men who sweat profusely. It is seldom seen before the age of thirty, except in children suffering from threadworms. The itching comes on gradually and usually intermittently, but grows progressively worse and worse until it becomes torturing. In many cases it is at first noticed only when warm in bed; in other cases it exists day and night. A violent exacerbation may be excited by worry, anxiety, overwork, dietary indiscretion, a sudden change of temperature, and many other things. The itching finally becomes an unbearable agony, sleep, except in snatches, is impossible, the appetite disappears, the strength fails, and the sufferer may become a nervous wreck. In some cases of pruritus the anal folds are edematous, there are abrasions here and there from scratching, the area is white and moist and gives origin to a fine secretion; in other cases the mucous membrane is dry and fissured.

Treatment.—In every case first of all make a careful examination to find a probable or a possible cause, local, reflex, or constitutional, and endeavor to remove this supposed cause. Then undertake treatment for the pruritus. It is very important to prevent constipation. Kelsey directs that the parts be cleansed twice a day, and after each cleansing that the following ointment be applied: menthol, ʒj; cerat. simp., ℥ij; oil of sweet almonds, f℥j; acid. carbolic., ʒj; pulvis zinc. oxid., ℥ij. Mathews commends the following mixture: chloral, ʒj; gum-camphor, ʒss; glycerin and water,

each, ℥j.* In this disease a "scarf skin" forms, which must be made to peel off by the application of iodin, pure carbolic acid, corrosive sublimate (gr. iv to ℥j of cosmolin), calomel (ʒij to ℥j of cosmolin), or camphophenique. In obstinate cases paint the parts, night and morning, with a mixture of 60 gr. of alum, 30 gr. of calomel, and 300 gr. of glycerin; or smear with an ointment composed of ½ part of oleate of cocain, 3 parts of lanolin, 2 parts of vaselin, and 2 parts of olive oil (Morain). In very severe cases in which the skin is dry and cracked, apply a 5 per cent. solution of eucain to the abraded portions and paint the entire surface with a concentrated solution of silver nitrate. It may be necessary to repeat this treatment several times at intervals of four or five days. Adler advised us to apply to the parts the day after the silver has been used unguentum hydrargyri nitratis in full strength, only discontinuing on the day a fresh application of silver is made and the next day resuming the applications of ointment. If during treatment the skin becomes sore, use calomel ointment until soreness disappears. Violent attacks of itching are met by applying hot water and black wash or calomel ointment. This plan of treatment must be pursued for some months (Lewis H. Adler, Jr., "New York and Phil. Med. Jour.," July 29, 1905). I have used this plan with some satisfaction. In severe and protracted cases we may employ the *x*-rays twice a week (J. R. Pennington). I have seen their application productive of great benefit. In some cases we employ the Paquelin cautery, in others we resect the mucous membrane, as in Whitehead's operation for hemorrhoids.

Fissure of the anus is an irritable ulcer at the anal orifice producing spasm of the sphincter. Pain exists because twigs of nerves are exposed upon the floor of the ulcer. Fissure is caused by constipation or traumatism. The **symptom** is violent, burning pain, sometimes beginning during defecation, but usually at the end of the act, and lasting for some hours. Constipation exists, and often pruritus. Examination discloses a fissure, usually at the posterior margin, running up the bowel one-quarter to one-half an inch. Piles often exist with fissure.

Treatment.—The *palliative treatment* is to prevent constipation, to wash out the rectum with cold water, and apply an ointment made by evaporating ℥ij of the juice of conium down to ʒij, and adding it to ℥j of lanolin and gr. xij of persulphate of iron. Pure ichthyol may do good. The *operative treatment* is to stretch the sphincter. Stretching gives us room in which to work, and, by thus paralyzing the muscular fibers, the raw surface is put at rest and paroxysms of pain cease to occur. In order to stretch the sphincter the patient is anesthetized, the surgeon's thumbs are inserted into the rectum, and the parts are stretched until the thumbs touch the ischia. After stretching the sphincter incise the floor of the fissure, scrape it with a curet, search carefully with a probe to be sure no pockets exist, and touch it with nitrate of silver stick.

Hemorrhoids, or Piles.—There are three varieties of varicose tumors of the rectum, namely: *internal*, which take origin within the external sphincter; *external*, which take origin without the external sphincter; and *mixed* hemorrhoids, which are a combination of the two.

External hemorrhoids are covered with skin. Internal hemorrhoids are

* "Diseases of the Rectum."

covered with mucous membrane. The term external hemorrhoids is not strictly accurate, as hemorrhage does not occur in external piles, and all external piles are not related to the external hemorrhoidal veins. An external pile may involve the veins or the skin.

External Hemorrhoids.—External hemorrhoids are classified as thrombotic, varicose, inflammatory, and connective-tissue external hemorrhoids (Tuttle).

Thrombotic External Hemorrhoids.—These are external hemorrhoidal veins filled with clot. When an external hemorrhoidal vein inflames, the parts become itchy, painful, and swollen, and defecation increases the pain. The blood clots in the inflamed vein and sometimes the vessel ruptures.

Symptoms and Treatment.—External piles of this variety are usually, but not always, multiple. Small oval tumors appear beneath the skin or the junction of the skin and mucous membrane. They appear suddenly. The parts itch and pain, defecation increases the pain, and each pile increases rapidly in size. When the vein ruptures, a livid, soft enlargement rapidly forms. External piles of this variety may be absorbed, may become organized into a scar, or may suppurate. These piles do not bleed. In treating external hemorrhoids some surgeons merely use remedies to combat the inflammation. An old plan of treatment is to incise the blood-tumor, turn out the clot, and pack with a bit of iodoform gauze. Mathews freezes the part or injects cocain, catches up the blood-tumor with a volsellum, excises the tumor and the tabs of inflamed skin, dusts the part with iodoform, and dresses it with antiseptic gauze. The bowels should not be allowed to move for two days. Never inject external piles with carbolic acid; it causes great inflammation, violent pain, and is not free from danger. If the patient declines operation, order rest, a non-stimulating diet, avoidance of tobacco (Mathews), the use of saline purgatives, injections into the rectum of cold water several times a day, sponging of the anus frequently with hot water, and the application of hot poultices. As the acute symptoms begin to disappear use lead-water and laudanum; when they have nearly subsided apply zinc ointment. Extract of hamamelis is a valuable application to external piles.

Varicose External Hemorrhoids.—These are varicose external hemorrhoidal veins and are visible at the anal margin when the patient strains. They rarely produce pain or discomfort, and it is seldom that operation is necessary. The bowels should be moved daily, but not with violent purgatives, and after each movement cold should be applied to the anus, while the patient is recumbent. Tuttle advocates the use at night of an ointment containing ʒij of suprarenal extract and ʒvj of lanolin. The ointment is spread on cotton-wool, which is applied to the anus and held in place by a T-bandage.

Inflammatory Piles.—By this term we mean edematous inflammation of the anal folds. The inflammation may be due to a traumatism, the presence of an ulcer or fissure, etc. There are burning, itching, and swelling of the anus, which are greatly increased by defecation. One or more pear-shaped swellings can be seen at the anal margin.

In some cases medical treatment produces cure. This treatment consists, during the first twenty-four hours, in the use of cold and of rest in bed. After

this period heat should be employed. Tuttle applies gauze soaked in a 25 per cent. solution of boroglycerid and places a hot-water bag over this. He also recommends the following ointment to be applied two or three times a day:

℞. Morphinæ sulph., ... gr. v–x
Ichthyol, ... ʒ iv
Ung. belladonnæ,
Ung. stramonii, } .... āā ʒj.
Sig.—Apply two or three times a day.

If these means fail, ether is given, the sphincter is stretched, and the tumors are cut away.

Connective-tissue External Hemorrhoids (Skin Tabs).—They are due to hypertrophy of mucocutaneous tissue at the anal margin. Usually they result from acute inflammatory external piles; sometimes they arise gradually as a result of chronic anal or rectal inflammation or irritation, and they may be due to varicose or thrombotic external piles (Tuttle). They produce no trouble when not inflamed. The treatment, if they cause serious annoyance, is extirpation.

Internal hemorrhoids are varicose tumors of the internal hemorrhoidal plexus, and are found internal to the external sphincter, just within the anus, and they prolapse easily. They are not simply varicosities, but new tissue has been formed, and they are in reality vascular tumors. They are covered with mucous membrane. *Capillary* piles are small, sessile, with a surface like a mulberry, and bleed freely. Children are not very liable to develop piles, excepting the capillary form. *Venous* piles are the most common variety. They extend from just above the anal margin of the rectum for an inch or more. They are purple in color, soft, irregular in outline, and are usually multiple. They bleed when irritated by hard fecal masses, but not so easily as the capillary piles. Each pile is composed of a varicose vein, some fibrous tissue, and a few arterial twigs. *Arterial* piles are very unusual. They are large, smooth, pedunculated, bleed easily and freely, and contain, besides a distended vein, arteries of some size.

Anything producing venous congestion in the rectum—constipation, diseases of the rectum, enlargement of the prostate, pregnancy, tumors of the womb, congestion of the liver, cirrhosis of the liver, certain diseases of the heart and lungs, sedentary occupations, relaxing climate, and stricture of the urethra—will cause hemorrhoids.

Symptoms and Treatment.—If there is neither bleeding nor protrusion, the piles give no trouble. The first symptom is usually hemorrhage, and rectal examination by the speculum will make clear the condition. After a time, during defecation, the piles protrude; they may reduce themselves when the patient stands up, or it may be necessary to push them in. Pain does not exist in uncomplicated cases, and pain during or after protrusion means "abrasion, fissure, or ulceration" (Mathews).

Palliative Treatment.—This will not cure, but it will give great comfort. Some people only suffer at rare times when the liver is congested, and such subjects will not submit to operation. Remove, if possible, the cause (alcohol, irritating foods, want of exercise, etc.); restrict the diet; insist on regular exercise; give a course of Carlsbad salt, and follow this by the administration of

bichlorid of mercury (gr. $\frac{1}{24}$ after each meal). Prevent constipation by a nightly dose of extract of cascara. After each bowel movement wash the parts with a soft sponge soaked in cold water and syringe out the rectum with cold water, and dry outwardly with a soft rag. If the hemorrhoids prolapse, after restoring them and injecting cold water, insert a suppository containing gr. v of the extract of hamamelis, and use another suppository at bedtime. A useful suppository for prolapse is that employed by Tuttle: it contains gr. v of ichthyol, gr. v of tannic acid, gr. $\frac{1}{3}$ of ext. of stramonium, gr. $\frac{1}{3}$ of ext. of belladonna, and gr. x of ext. of hamamelis. Bleeding may be arrested by suppositories, each containing gr. v of suprarenal extract. When the piles prolapse and inflame, rub Allingham's ointment on the parts (ʒij each of ext. of conium and ext. of hyoscyamus, ʒj of ext. of belladonna, and ℥j of cosmolin). Mathews uses gr. xij of cocain, ʒj of iodoform, ʒss of ext. of opium, and ℥j of cosmolin. Gant uses an ointment containing gr. viij of morphin, gr. xij of calomel, and ℥j of vaselin. This is applied after bathing the part with hot water. If the piles are protruding and reduction cannot be effected, put the patient to bed, give a hypodermatic injection of morphin, and apply hot poultices. If reduction cannot soon be effected, divulsion of the sphincter must be practised or radical operation must be resorted to.

Operative Treatment.—Give a saline the morning before, and an enema the evening before, the operation, and wash out the rectum well the morning of the operation. In treating by *injection of carbolic acid* the sphincter should be divulsed while the patient is under the influence of nitrous oxid gas. "Under gas muscular relaxation does not obtain as in the use of ether. Hence dilatation under gas can be more rapidly induced, as we have the sphincteric rigidity as a guide in knowing exactly how much force may be employed in the individual case" (Lewis H. Adler, Jr., in "Jour. Am. Med. Assoc.," Jan. 21, 1905). The surgeon must be careful not to tear the parts. The tumors are drawn out or, if gas was not given, the patient strains them out, an injection is given by a hypodermatic syringe into the center of the pile, and as each pile is injected it is pushed into the rectum. But one or two piles are injected at each séance, and the operation is not repeated for one week (Geo. W. Gay, in "Boston Med. and Surg. Jour.," Dec. 5, 1901). The dose for each pile is ♏j or ♏ij of a 10 per cent. solution of pure carbolic acid. The injections relieve the condition, but are rarely absolutely curative, and are not without danger, and may produce, it has been said, hemorrhage, phlebitis, pyemia, stricture, and even death (W. T. Bull). Dr. Collier F. Martin ("American Medicine," August 27, 1904) maintains that the method is safe and satisfactory. He injects equal parts of phenol boboeuf and distilled water, freshly mixed and filtered. From 7 to 15 minims are injected into a pile, and only one pile is injected at a séance. In from five days to one week another injection may be given. Before beginning a course of injections the sphincter is stretched while the patient is under nitrous oxid and oxygen. It is not necessary to repeat this for future injections. During injection a special speculum is used. The pile protrudes into the speculum, is cleansed with a 1 per cent. solution of creolin and the injection is thrown into the most prominent part of the pile. The speculum is withdrawn before pulling out the needle. This maneuver prevents escape of injection and bleeding. The *clamp and cautery* is, in the great majority of cases, the operation of choice. It requires but a few

minutes to do it; after it is done there is little or no postoperative pain, in very many cases retention of urine does not occur, and the patient usually is about again within ten days. The patient is anesthetized and the sphincter is carefully and thoroughly stretched. The stretching of the sphincter is very important. It gives free access to the parts, prevents subsequent spasm

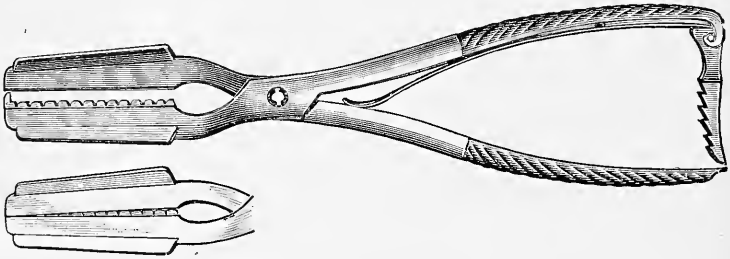


Fig. 610.—Brick's pile clamp.

and pain, and lessens the likelihood of venous bleeding after operation. The pile is caught with forceps and drawn outside of the sphincter. Many use Smith's clamp. It is applied with the ivory surface against the mucous membrane of the bowel. I use the clamp devised by Dr. J. Coles Brick (Fig. 610). From the bite of Brick's clamp the pile cannot slip as the blades come evenly and firmly together. The pile is cut off, and the stump is seared with the Paquelin cautery at a dull-red heat. Pile after pile may be thus treated, care being taken to leave some mucous membrane at each side of every pile. If this precaution is not taken, healing will be slow and stricture will result. After cauterization is complete a speculum is inserted and the blades are widely opened. Any bleeding point is at once ligated. Packing is never inserted. I formerly used it but have given it up. It is of no service and produces severe pain and edema. The treatment from this point is identical with that advised below after the use of the ligature. *Excision* is preferred by Allingham. He stretches the sphincter, holds it open with a retractor, catches up the pile, cuts it off, and twists the bleeding vessels. Some prefer to pass a silk or catgut suture, cut off the tumor, and tie the thread (Fig. 611). *Whitehead's operation* (Fig. 612) is only to be performed in severe cases, when the piles are extremely large and form a protruding circular mass. Primary union is rarely secured. When first introduced, the operation

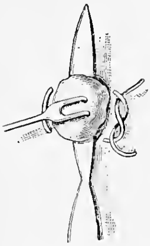


Fig. 611.—Extirpation of hemorrhoids (Esmarch and Kowalzig).

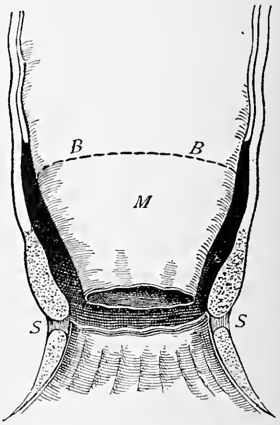


Fig. 612.—*S*, *S*, The lower circular incision along Hilton's white line; *M*, Tube of mucous membrane dissected from the sphincter; *B*, *B*, dotted line showing the place for the upper circular incision (Edmund Andrews).

was viewed with favor, but experience shows it is sometimes followed by disastrous consequences.* Stricture not infrequently arises after its performance; fecal incontinence occasionally results, and anal anesthesia with inability to restrain the passage of gas is common. After this operation the anus is permanently more or less moist. The entire pile-bearing area of mucous membrane is dissected out, and the cut margin of mucous membrane is pulled down and stitched to the surface. The sphincter may be dilated as a preliminary measure.

The *application of the ligature* is an easy and useful method. It is not so rapid as the cautery, is followed by more pain, healing requires a longer time, and stricture is more common. In this operation, after anesthetizing, stretch the sphincter and treat each hemorrhoid separately. Catch a pile

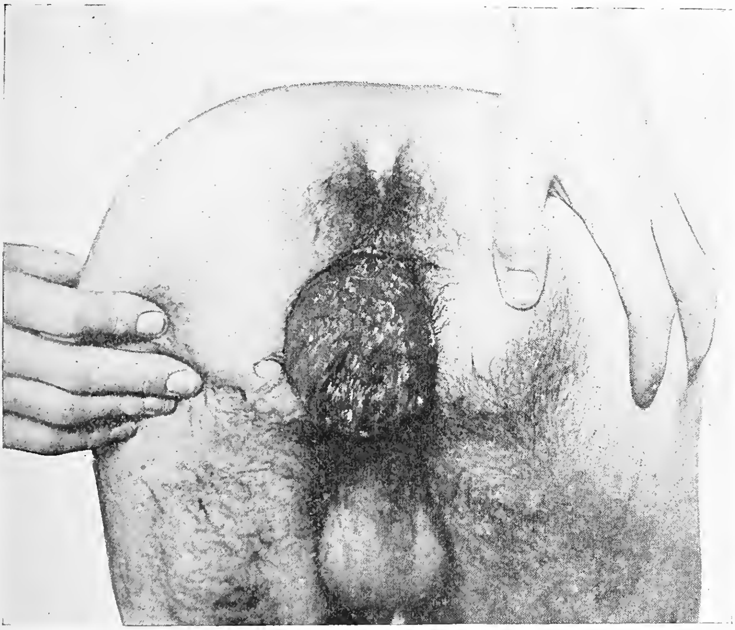


Fig. 613.—Rectal prolapse.

with a pair of forceps or a volsellum, pull it down, and cut a gutter through the skin-margin if the pile is of the mixed variety; tie the small piles without transfixing, but transfix the large piles; tie with silk (coarse silk for the large piles, finer silk for the small piles); cut off each tumor beyond the thread, and cut the ligatures short. Treat the other piles in the same manner. Irrigate with hot normal salt solution. Do not insert packing. Apply a gauze pad and a T-bandage. Give some morphin to lock up the bowels, and keep the patient on a light diet for three days, at the end of which time a saline may be given. Just before the bowels act remove the dressings and give an enema of warm water or of glycerin. After the movement wash out the rectum first with dilute peroxid of hydrogen and next with hot salt solution, dust with iodoform, and apply a gauze pad over the anus. Irrigate daily

* Andrews, in Mathews' Medical Quarterly, Oct., 1895.

until healing is complete. After the tenth day examine with a speculum to see that the ligatures have come away; if any are found in place, remove them.

Prolapse of Anus and Rectum.—If the mucous membrane is prolapsed, the condition is called "*prolapsus ani*"; if the entire thickness of the rectal wall is prolapsed, it is called "*prolapsus recti*" (Fig. 613). The commonest form is due to relaxation of the submucous connective tissue permitting the protrusion of a ring of mucous membrane. Prolapse is apt to occur from excessive straining at stool and is commonest in feeble, ill-nourished children. Piles and worms may lead to prolapse. Straining from phimosis, stone in the bladder, or urethral stricture may be causative. Its development is favored by the use of articles of food which cause frequent

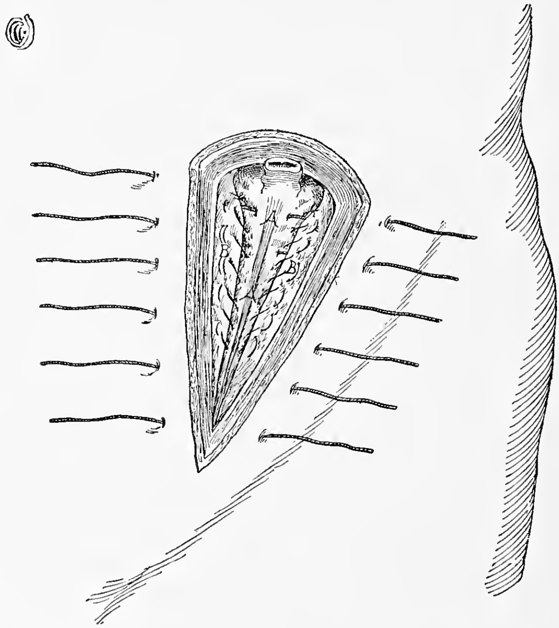


Fig. 614.—Joseph D. Bryant's method of colopexy; *A*, *A*, Longitudinal band, with sutures passed behind it, including peritoneal and muscular coats of the intestines, drawn forward; *B*, *B*, parietal peritoneum quilted to sides of the intestine, showing stitches; *C*, old fecal fistula.

movements of the bowels. If an individual sits a long time on the seat of the closet or on the chamber, the development of prolapse is favored. Prolapse may be either large or small, but tends to recur again and again, and eventually the mucous membrane inflames, ulcerates, or sloughs. Strangulation of the prolapsed part may occur. The condition is sometimes confused with hemorrhoids, but in prolapse the protruding mass is circular and has a depression in the center (Fig. 613), whereas hemorrhoids are distinct masses. Further, hemorrhoids are very rare in children. A polypus is a single tumor with a pedicle.

Treatment.—*Palliative* treatment forbids straining at stool and amends an improper diet. Phimosis must be corrected; stone in the bladder must

be crushed or removed. If prolapse occurs, the protrusion must be bathed with cold water and restored. Constipation must be prevented (enemata of water or glycerin may be used), and after each movement several ounces of a solution of white oak bark should be injected. If a prolapse is caught firmly, place the patient in the knee-chest position, wash the mass with cold water, grease it with cosmolin, insert a finger into the rectum, and apply taxis around the finger (Mathews). If this fails, cover a finger with a handkerchief and insert the wrapped digit into the rectum; if this proves futile, invert the patient. Severe cases require ether before reduction is attempted. After reduction apply a compress, direct it to be worn except when at stool, and before each act of defecation give an injection of cold water containing an astringent (tannin or fluid ext. hydrastis). A useful treatment in many cases is to paint the prolapse with fuming nitric acid, grease it with olive oil, and restore it. Some cases require excision of the mucous membrane, the divided edge of this membrane being stitched to the skin. In other cases the protrusion is stroked with a cautery and restored. When the surgeon comes to operate for recurring prolapse, it will often be found to have modestly withdrawn and he may be obliged to stretch the sphincter to bring it into view. In persistent cases of rectal prolapse open the abdomen and attach the colon to the belly-wall (*colopexy* or *sigmoidopexy*, Fig. 614).

Ulcer of the Rectum.—Ulcers of the rectum are divided into the simple traumatic, the syphilitic, the tuberculous, the dysenteric, the gonorrheal, and the malignant. *Simple* ulceration is due to abrasion with fecal masses or a foreign body, the abraded area ulcerating. It may follow an operation for piles and also protracted labor (Allingham), and is apt to be single. The base and edges of a simple ulcer are neither prominent nor hard, and stricture rarely forms. *Syphilitic* ulceration is a tertiary lesion commonest in women. There are numerous small ulcers of the mucous coat or submucous tissue, but little indurated, with sharp-cut edges which are not undermined. These ulcers fuse and constitute one large irregular ulcer; fibrous tissue forms in the wall of the bowel, induration becomes noticeable, and stricture follows. There is profuse discharge, and fistulæ are apt to form. Such ulcers may be surrounded by nodules of a bluish color. In many cases the first condition is stricture due to the formation of masses of fibrous tissue in the rectal walls, and ulceration occurs secondarily (Fournier). In syphilis there may be a breaking down of a huge gummy mass or of multiple gummata. It has been proved by the microscope that tuberculous ulceration may arise in the rectum. *Tuberculous* ulceration presents a conical ulcer with overhanging edges and a pale-red base. There is some mucous discharge, some tenesmus, and a little pain, but a stricture rarely forms. Dysentery, catarrh, neoplasms, and foreign bodies may produce ulceration of the rectum.

Symptoms.—There may be merely uneasiness about the rectum, but sometimes there is severe burning pain on defecation. and perhaps for some time after the act. There may be constipation or diarrhea, the patient strains at stool, and the stools may contain blood, mucus, or pus. As a rule, there is diarrhea on rising in the morning, the first movement consisting of blood and mucus, and the next movement being fecal. The history should be carefully inquired into; tuberculosis should be sought for; the question of syphilis should be investigated. A digital examination enables the surgeon to feel the

ulcer, and an examination with an ordinary speculum or an electric proctoscope brings it into view.

Treatment.—In *simple* ulcer empty the bowel by the administration of a saline cathartic, wash out the rectum with hot water after the saline has acted, introduce a speculum, touch the ulcer with pure carbolic acid or silver nitrate (gr. xl to ℥j), place the patient in bed, restrict him to a liquid diet, and every day inject iodoform and olive oil or insufflate iodoform into the rectum. If this fails, give ether, stretch the sphincter, incise the ulcer through its entire thickness, and cauterize with fuming nitric acid, caring for the case subsequently as we would a patient who had had piles ligated. In *tuberculous* ulcer improve the general health, send the patient to a genial climate, or at least into the sunlight and fresh air, prevent constipation, give nutritious food, especially fats, wash out the rectum every day with hot water, and insufflate iodoform or inject iodoform emulsion. Touch the ulcer once a week with silver nitrate (gr. x to ℥j). In *syphilitic* ulcer give antisyphilitic treatment and treat the ulcer locally as is done in tuberculous ulcer. *Dysenteric* ulcer requires injections of hot water, the touching of the ulcer with pure carbolic acid, and insufflations of iodoform.

Non-cancerous stricture of the rectum may be congenital or acquired. There are two forms of acquired stricture: first, stricture due to external pressure; second, stricture due to primary narrowing of the rectal wall.* Stricture due to external pressure is very rarely complete, and may be caused by bands of adhesions or a malignant growth. The second form may be produced by syphilitic tissue, ordinary inflammatory tissue, cicatrices after operations, sloughing, tuberculous, syphilitic, or dysenteric ulceration, rectal gonorrhea, and traumatism. The usual seat of simple stricture is from one inch to one and a half inches above the anus. The deposit may be limited to the submucous coat or all the coats may be involved. It is very seldom that stricture arises as a result of abrasion from fecal masses or foreign bodies. It may follow an operation for piles if considerable tissue is removed, and is an occasional sequence of Whitehead's operation. Stricture due to dysentery is extremely rare, and no case has ever been reported to the United States Pension Office (Peterson). The existence of stricture as a result of rectal gonorrhea has not been positively proved. A majority of sufferers from rectal stricture have labored under syphilis, but it is not probable that the lesion is syphilitic in all or even in most of them. The stricture may be due to the formation of fibrous tissue, and ulceration may or may not occur. It may be caused by the contraction and healing of a large ulcer. Some maintain that tuberculous stricture does occur. Mathews dissents from this view and points out that the disposition of tuberculous matter is to break down, and before the rectum can be strictured from tuberculosis it breaks down from ulceration. Peterson † says a large proportion of the victims of rectal stricture die of phthisis, and also that one-third of so-called syphilitic cases are tuberculous. It may begin as an ulcer or as an infiltration of submucous tissue. Although a syphilitic lesion or a tuberculous lesion may cause rectal stricture, in most cases such lesions simply expose the tissues to infection, and a benign rectal stenosis results from the

* Reuben Peterson, in Jour. Amer. Med. Assoc., Feb. 3, 1900. † *Ibid.*

infection. Hence tuberculosis causes stricture but does so indirectly rather than directly.

The **symptoms** of rectal stricture are constipation, pain on defecation, straining at stool, the presence of blood and mucus in the stools, an open anus, and the passage of stools flattened out into ribbons. In some cases there is fluid diarrhea, solid fecal matter being retained above the stricture. The stricture is found by the finger or by the bougie. In syphilitic cases, in tuberculous cases, and in benign cases the fibrous thickening is usually in the submucous coat, and in syphilitic and tuberculous cases the mucous membrane is apt to ulcerate. It is said that complete obstruction may arise. I have seen obstructive symptoms, but never *complete* obstruction in rectal stricture. Distention of the abdomen and colic are very usual.

The **treatment** of non-cancerous stricture is rest, non-stimulating diet, warm-water injections, mild laxatives, and hot hip-baths. Cocain suppositories may be needed. Any existing disease is treated. Bougies are passed every other day. Use a soft-rubber bougie, warmed and oiled, and introduce it gently. If only the method of gradual dilatation is employed, the patient must for the remainder of his life pass a bougie from time to time. For fibrous strictures forcible dilatation (*divulsion*) by a special instrument is employed or incision is practised. Incision (*proctotomy*) may be either external or internal. In internal proctotomy one or more incisions are made through the stricture down to healthy tissue, the first cut being in the middle line posteriorly. External proctotomy, which divides the sphincters, is apt to leave incontinence as a legacy. Electrolysis finds some advocates, but on what grounds it is difficult to see. In some cases the rectum should be removed. In incurable cases perform inguinal colostomy.

Cancer of the rectum is the cancer of the bowel most often met with. It may be primarily malignant or may arise from an adenoma. The commonest growths are composed of cylindrical cells, and may be soft or scirrhous. In cases secondary to epithelioma of the anus ordinary epithelioma arises.

In most rectal carcinomata the cells present a tubular arrangement surrounded by a more or less plentiful stroma of connective tissue. In soft tumors the connective tissue is scanty; in hard tumors it is plentiful.

Cancer is most common after the age of forty, but it not unusually occurs before the thirty-fifth year, and is sometimes seen even as early as the twenty-fourth year. Extensive ulceration occurs. If a hard ring encircles the rectum, the lumen of the tube is greatly and progressively diminished. In cases of diffuse infiltration the lumen is not greatly lessened. In growths of the anus the inguinal glands are involved and also the glands in the hollow of the sacrum. In growths of the rectum proper the glands back of the peritoneum in the sacral hollow are involved, and the inguinal glands are involved late or not at all.

Symptoms.—The *symptoms* of rectal cancer are like those of non-malignant stricture, except that the pain is usually greater, the hemorrhage more severe, and constipation is apt to alternate with diarrhea. The diarrhea is usually in the morning. Unfortunately, in many cases symptoms are long trivial; in fact, pain may be absent until the disease is far advanced. Mucopurulent or bloody stools are often thought to result from dysentery or hemorrhoids, which latter condition, however, may be only an accompanying condition of rectal cancer. Or the above symptoms may, on the patient's say-so,

have been accepted by the physician as caused by hemorrhoids, without any local examination. The patient again may have only imagined the presence of hemorrhoids, since, according to his notion, the above symptoms must result from hemorrhoids, with which condition so many of his friends with like complaints are afflicted. Loss of strength, emaciation, and cachexia are generally noticeable only in the late stages of rectal cancer. Only in the very latest stages the characteristic odor is perceptible, the patient becomes septic, and abscesses attended by gangrene may form (Ernest Jonas, in "Interstate Med. Jour.,"

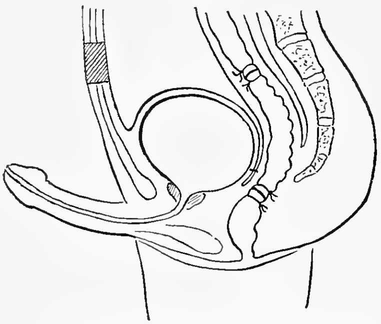


Fig. 615.—Tying off the tumor through an abdominal incision after separating peritoneum from sacrum and bladder (Weir).

Fig. 616.—Lower end of rectum everted through the anus and the upper end of bowel drawn out of the abdominal cavity (Weir).

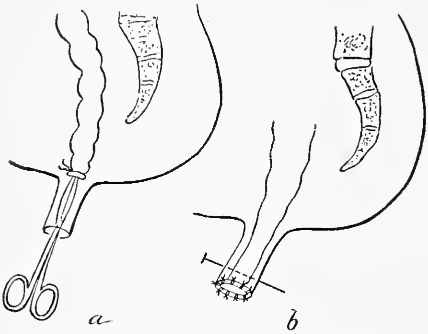


Fig. 617.—*a*, The upper bowel drawn out through the everted lower end of rectum; *b*, the ends of the two portions of the rectum sewn together (Weir).

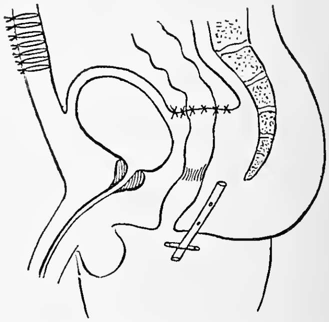


Fig. 618.—The united bowel replaced with posterior drainage and the divided peritoneum so sewn together as to shut off the general peritoneal cavity from the pelvis (Weir).

No. 4, 1906). The finger and the speculum make the diagnosis. In rectal cancer metastasis occurs late. The most favorable cases for operation are those in which the growth is small and movable. Accurately define the extent of the growth, and endeavor to make out if it has invaded the cellular tissue outside of the rectum, the prostate, the bladder, the sacrum, the uterus, etc.

Treatment.—In every case of cancer of the rectum the following question must be considered: Shall we perform a radical operation in hope of producing cure or at least greatly prolonging life? In what cases should a radical operation be attempted? It is the proper procedure if there are no metastatic deposits, if the patient is in fair general condition and free from serious

organic disease, and if the cancerous bowel is movable and not fixed by dissemination to adjacent structures. As W. Watson Cheyne says ("Brit. Med. Jour.," June 13, 1903), a slight adhesion to the vagina is not a contraindication because this portion of the vagina can be readily removed with the diseased rectum. Some surgeons will not attempt radical operation if they cannot pass a finger through the growth. I do not regard high position as forbidding operation, although, of course, it makes it more dangerous to life and less promising as to cure. Cheyne is of the same opinion. When the surgeon is first called to a case of cancer of the rectum it is usually found to be so far advanced as to be inoperable. In at least 75 per cent. of my cases radical extirpation was impossible when I first saw the case.

If a radical operation is determined on, the next question to answer is, Shall we, or shall we not, do a *preliminary colostomy?* If the cancer is very low down and is to be removed from the perineum, preliminary colostomy should not be done. If the cancer is high up and we propose to attack it by Weir's method, or the Quenu-Mayo method, preliminary colostomy should not be done. If Kraske's operation is to be performed, I believe preliminary colostomy is indicated. It enables us to cleanse the area upon which operation is to be performed, and to keep the wound clean, and gives us a much better chance of obtaining primary union. In cases in which the sphincter is retained and it is possible to anastomose the divided ends of the rectum together, colostomy is not necessary; and if an artificial anus has been made in such a case, another operation will be required to close it. As a matter of fact, I have found it always difficult and usually impossible to suture the divided ends of the gut together after Kraske's operation, and I now follow the advice of Keen, and always precede it by a colostomy. If radical operation is rejected (and about three-fourths of the cases, when first seen by the surgeon, are beyond such aid), palliative treatment is desirable. One plan is to every day introduce a tube through the stricture, wash out the rectum with warm water, and after washing inject emulsion of iodoform (gr. x to ℥j of sweet oil). Injections of chlorid of zinc (gr. j to ℥j of water) lessen the foulness of the discharge. The bowels are opened regularly by laxatives, and if the growth causes obstructive symptoms, it is scraped away with a sharp spoon. Opium is given to relieve pain. The advantage of this plan is that the patient does not suffer from the unpleasantness of an artificial anus. Sooner or later, however, the growth gets outside of the bowel, and terrible pain will arise from involvement of the sacral plexus. W. Watson Cheyne ("Brit. Med. Jour.," June 13, 1903) would restrict palliative treatment of this character to cases in which fungating masses grow from one side of the bowel.

If a growth encircles the bowel and produces symptoms of obstruction, *palliative colostomy* should be performed. This operation gives great comfort to the patient, and allays pain by intercepting the feces before they reach the cancer. I am not convinced that it distinctly retards the growth of the cancer or notably prolongs life. Unfortunately, colostomy does not do away with pain if the sacral plexus is involved. I have had no experience with radium in inoperable cancer of the rectum and have never seen the *x*-rays produce any marked or lasting improvement. *Operative treatment* includes one of several procedures. Excision of the

rectum from below (*Cripps's operation*) is practised if not more than three inches require removal, if the peritoneum is not invaded, and if the adjacent organs are free from disease. The peritoneum must not be opened in Cripps's operation. After the growth is removed the divided rectum is pulled down and sutured to the skin. Excision of the rectum after excising the coccyx and a portion of the sacrum (*Kraske's operation*, Fig. 619) is a procedure which permits removal of the entire tube, portions of the colon, and even of adjacent parts. The peritoneum is opened deliberately in this operation, and is subsequently closed with sutures before the gut is opened. The glands from the mesocolon are always removed. The lower end of the upper segment of bowel is fastened in the wound, or, if colostomy has been previously performed, may be closed. In some few cases in which it is not necessary to remove the lower end of the rectum, the two portions may be anastomosed after resection of a part of the tube. Kraske's operation may be done by an osteoplastic method, the bone not being removed. It is well to precede a Kraske operation two weeks by an inguinal colostomy, which permits of cleansing the lower bowel of feces and lessens the chance of severe wound-infection and delayed healing after the removal of the rectum. A preliminary colostomy may make the operation of extirpation more difficult by fixing the intestine, and thus interfering with the necessary drawing down of the gut (E. H. Taylor). If the growth is extensive and the mesocolon short, it may be best to perform a right inguinal colostomy; but in most cases left inguinal colostomy is preferred (Gerster). The colostomy remains open during the patient's life, except in those rare cases of Kraske's operation in which the continuity of the rectum can be reëstablished after excision of the growth. In such cases the artificial anus may be closed some time after the resection of the rectum.

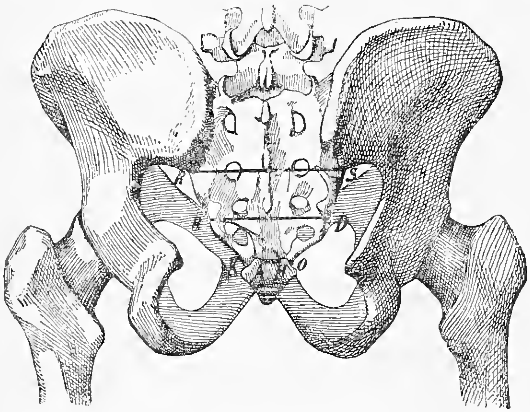


Fig. 619.—Different levels of resection of the sacrum: *K O*, Kocher's line; *B*, *O*, Kraske's; *B*, *H*, Hochenegg's; *B*, *D*, Bardenheuer's; *R*, *S*, Rose's (Mass.).

Robt. F. Weir ("Med. News," July 27, 1901) has been so much impressed with the difficulties and dangers of Kraske's operation in a case of high carcinoma that he now employs it solely in cases in which there is freedom from disease for two inches immediately above the anus and in which the cancer does not extend more than five inches above the anus. In other cases he does the following operation: Open the abdomen above the pubes, separate the peritoneum so that the bowel and "contents of the sacral curve" are liberated behind nearly "to the tip of the coccyx and in front of the edge of the prostate." The tumor is then tied off with tapes (Fig. 615). The portion of the rectum bearing the tumor is removed, the lower end of the bowel is everted through the anus, and the upper end is drawn out of the

abdominal incision (Fig. 616). The upper end is then caught with forceps and drawn through the everted lower end of the rectum (Fig. 617, *a*). The ends of the two everted portions (Fig. 617, *b*) are sewn together, the everted bowel is replaced, the divided peritoneum is sutured to shut off the peritoneal cavity, and posterior drainage is inserted (Fig. 618). In the Quenu-Mayo operation the object is to remove all of the diseased glands as well as the cancer (W. J. Mayo in "St. Paul Med. Jour.," April, 1906. J. Coles Brick at meeting of American Proctologic Soc., June, 1906.) The patient is placed in an exaggerated Trendelenburg position and the belly is opened by a median incision. The growth is studied to see if it is removable, and a search is made for enlarged glands which might and for secondary growths which would cause us to abandon the operation. If we conclude to attack the growth, pack away all the intestine except the sigmoid, catch two clamps across the sigmoid, one of them being on the level of the sacral promontory. Divide the gut between them. Free the meso-sigmoid by lateral cuts and bring the proximal stump out of the belly, ligate it, and apply a purse-string suture to invert it. A gridiron incision is then made on the left side and the proximal stump is pulled through it and is sutured there. Incisions are now made in the sides and in front to liberate the rectum, the inferior mesenteric artery is tied above and to the left of the promontory, the fat and glands are thoroughly removed from the sacral hollow, vessels being tied as cut, except the middle sacral and middle hemorrhoidal vessels, which are tied before division. The area is now packed with gauze and the patient is put in the lithotomy position. The rectum is packed with gauze, the anus is sutured, and the rectum is separated from the prostate and urethra or from the vagina from below upward to just above the levator ani muscle. An assistant presses the fragment carrying glands down from the abdomen and the surgeon removes it from the perineum. The peritoneum is sutured within the abdomen, room being left for a small drain which protrudes from the perineum. The perineal wound is narrowed by sutures and the wound in the belly is closed. In twenty-four hours the protruding end of the sigmoid is opened and an artificial anus is thus made.

The mortality of Kraske's operation is from 12 to 15 per cent. Twenty-eight per cent. of Kocher's cases of extirpation of cancer of the rectum remain well from three to sixteen years after operation (W. W. Cheyne, "Brit. Med. Jour.," June 13, 1903).

XXIX. ANESTHESIA AND ANESTHETICS.

Anesthesia is a condition of insensibility or loss of feeling artificially produced. An **anesthetic** is an agent which produces insensibility or loss of feeling. Anesthetics are divided into—(1) *general anesthetics*, as amylene, chloroform, chlorid of ethyl, ether, bromid of ethyl, nitrous oxid, and bichlorid of methylene; (2) *local anesthetics*, as alcohol, bisulphid of carbon, carbolic acid, ether spray, cocain, eucain, stovain, ice and salt, rhigolene spray, and ethyl chlorid spray.

Anesthesia may be induced by a general anesthetic to abolish the usual pain of labor and of surgical procedures; to produce muscular relaxation in tetanus, herniæ, dislocations, and fractures; and to aid in diagnosticating abdominal tumors, joint-diseases, fractures, and malingering.

Death-rate from Anesthetic Agents.—Hewitt combines the statistics of Julliard and Ormsby, with the following result ("Anesthetics and Their Administration"):

Anesthetic.	Total Number of Administrations.	Total Number of Deaths.	Death-rate.
Chloroform	676,767	214	1 in 3162
Ether	407,553	25	1 in 16,302

Hewitt finds that during the last forty years only thirty fatalities are recorded as produced by nitrous oxid, and he thinks several of these should be excluded. It is practically certain, however, that many deaths, or at least some deaths, have not been recorded.

Seitz collected 16,000 instances of anesthesia by chlorid of ethyl, with one death.

Preparation of the Patient.—Whenever possible, prepare a patient before administering a general anesthetic and prepare him, if the case admits of it, during two or more days. Heart disease is not a positive contraindication to surgical anesthesia. It is quite true that anesthetics are dangerous to people with fatty hearts, but shock is also dangerous, and the surgeon stands between the Scylla of anesthesia and the Charybdis of shock. Gallant truly says that not enough attention is paid to the "character of the pulse and action of the heart before operation, by which to compare its work during anesthesia, and after the operation is over, and this neglect leads to unnecessary stimulation and overdriving a heart which is doing its average best."* Always examine the urine if the nature of the case allows time. If albumin is found, operation is not contraindicated; but the peril of anesthesia is greater, and certain dangers are to be watched for and guarded against. If much albumin is present, postpone operation except in emergency cases. If sugar is found, the danger is considerable, as diabetic coma occasionally develops. The percentage of sugar does not determine the amount of danger. Coma may arise when only a little sugar is present, and may not arise when there is a considerable amount. The presence of aceto-acetic acid is more ominous than is the presence of sugar. Empty the intestinal canal by purgation a number of hours before anesthetization. It is well to give the bowel six to twelve hours' rest before operation. The usual custom is to give a saline cathartic the evening before operation and an enema early on the morning of the operation. Of course, frequently the nature of the case or the necessity for haste does not permit of preliminary emptying of the intestine by the administration of cathartics. During the twenty-four hours preceding operation food should be taken in small amounts and in forms easily digestible. During the day or so before operation there is usually impaired digestion, and no undue strain should be put upon the stomach. In the morning allow no breakfast if the operation is to be performed at an early hour; but if the patient is very weak, order a little brandy and beef-tea. If the operation is to be about noon, give a breakfast of beef-tea and toast or a little consommé; *never* give any food within three hours of the operation, but brandy is admissible if it is re-

* Medical Record, February 2, 1899.

quired. If the stomach is not empty at the time of operation, vomiting is almost inevitable, and portions of food may enter the windpipe; if the stomach contains no food, vomiting is far less likely to happen; and even if it occurs and vomited matter should enter the windpipe, it may do little harm, as it consists chiefly of liquid mucus. In cases of intestinal obstruction in which there has been stercoraceous vomiting there is much danger that vomiting will occur during anesthetization. In some cases of intestinal obstruction, during the administration of the anesthetic, and during the anesthetic state, a stream of stinking brown fluid may flow without effort from the mouth. Vomiting or regurgitation of stercoraceous material is profuse, sudden, and dangerous. It may flood the bronchial tubes during inspiration and cause death by suffocation. In a case in which stercoraceous vomiting has occurred wash out the stomach before administering the anesthetic. If a patient with intestinal obstruction is too weak to permit lavage, a local anesthetic should be used instead of a general anesthetic. Vomiting while the patient is under the influence of an anesthetic is dangerous in any case, because of the great cardiac weakness which precedes and follows it. If a patient sleeps well the night before an operation, he will probably take the anesthetic better than if he sleeps poorly. Effort should be made to obtain a night's sleep. An excellent expedient is a hot ammonia bath, followed by a rub-down with weak alcohol.* It may be necessary to administer trional or bromid. About fifteen minutes before giving the anesthetic let the patient drink a glass of hot water. This material protects the stomach from the irritant effects of any anesthetic which may be swallowed. Before giving the anesthetic see that artificial teeth are removed and that the patient does not have a piece of candy or a chew of tobacco in the mouth. Always have a third party present as a witness, because in an anesthetic sleep vivid dreams often occur, and erotic dreams in women may lead to damaging accusations against the surgeon. Place the patient recumbent. The effort should be to place him in as comfortable a position as possible if this position is consistent with operative necessities. See that the clothing is loose, particularly that there is no constriction about the neck and abdomen. Do not have the head high unless this position is demanded by the exigencies of the operation. The anesthetist must have a mouth-gag and a pair of tongue forceps. It is very wrong to say that a mouth-gag and tongue forceps are never necessary. It is quite true they are often used when not needed, but this does not justify us in being without them when they are needed, and they may be needed very badly. The anesthetist should also have a pair of artery forceps and some small gauze sponges to swab out the mouth and throat. A hypodermatic needle in *working* order, and solutions of strychnin, atropin, and brandy are to be in a readily accessible place, and it is well to have an electric battery and a can of oxygen at hand. Accidents, it is true, are rare, but they may happen at any time, and hence the surgeon should always be prepared for them. Any danger which arises must be met with promptness and decision, or action will be of no avail. Many surgeons give a hypodermatic injection of morphin a short time before operation, to steady the heart, to prevent vomiting during anesthetization, to shorten the stage of excitement, and to aid the bringing about of insensibility with very little of the anesthetic. There are, how-

* A. Ernest Gallant, Med. Record, Dec. 30, 1899.

ever, objections to morphin before anesthesia, and its use should be the exception and not the rule. It depresses the respiration, lowers temperature, and thus perhaps increases operative shock, interferes with the pupillary phenomena of anesthesia, delays awakening from the anesthetic sleep, and actually favors post-anesthetic vomiting. In some cases we may anticipate trouble from the anesthetic. Cyanosis may occur in drunkards; in fat, thick-necked individuals of the Major Bagstock type, who are short of breath and congested in appearance; in individuals with some disease of the lungs, bronchi, pharynx, larynx, or trachea (empyema, emphysema, chronic bronchitis, croup, cancer of the larynx, etc.); in individuals suffering from fatty heart or valvular incompetence. Buxton points out that an individual without teeth and with stenosis of the nares is apt to become cyanotic under an anesthetic, because the lips and pillars of the fauces are drawn in like valves during inspiration.

Ether and Chloroform.—The two favorite anesthetics are ether and chloroform. Only the very best ether or chloroform should be used. It is a good plan, in order to lessen bronchitis, to mix with ether turpentine of Pinus pumilio in the proportion of 20 drops to $6\frac{1}{2}$ oz. (Becker, in "Centralbl. f. Chir.," June 1, 1901). Chloroform is more dangerous than ether in general cases, though it is more agreeable, less irritant to the lungs and kidneys, and quicker in its action. Chloroform is a safer anesthetic in warm than in cold countries. In fact, in the tropics it is a matter of considerable difficulty to use ether because of its great volatility. Chloroform is preferred in campaigns, because less is required and transportation is easier. Recovery from chloroform is quicker and quieter than that from ether, but chloroform-vomiting lasts longer than ether-vomiting. Chloroform may induce sudden and even fatal syncope. Hare's experiments on animals indicate that chloroform may kill by respiratory failure occurring secondarily to failure of the vasomotor center; but certain it is that clinically the danger of chloroform is paralysis of the heart, and this condition may come on so rapidly that death may occur almost before an attempt can be made to save life. Leonard Hill has proved that most chloroform-deaths that take place after considerable of the anesthetic has been taken arise from paralytic distention of the heart. Sudden death, when inhalations of chloroform have just commenced, may be due to the irritant vapor acting on the nasal mucous membrane, exciting a nasal reflex and powerfully stimulating cardiac inhibition. If ether produces danger it does so usually through the respiration, and not the heart, and there is generally time to undertake means of resuscitation, which means are apt to be successful. Chloroform is to be preferred to ether in the following cases: for children under ten years of age, in whom ether causes a great outflow of bronchial mucus, which may asphyxiate; for people over sixty, entirely free from myocardial disease, at which age most persons have some bronchitis, and ether chokes them up with mucus. Ether also irritates the kidneys, which at the latter age are apt to be weak or diseased. Chloroform is given if the actual cautery is to be used about the face, neck, or mouth, because ether vapor may take fire and chloroform vapor will not. Chloroform is preferred for labor cases, when moderate anesthesia only is required, and for operations on the mouth and nose. In cleft-palate operations chloroform is usually preferred, because it causes but little cough and salivary flow.

In ligation of a large artery which is overlaid by a vein, ether exercises the unfortunate influence of greatly enlarging the vein. Hence in such a case chloroform makes the operation easier. In goiter operations ether should not be used, as it enlarges enormously the veins. In fact, most goiters should be removed with the aid of local anesthesia only. Chloroform is particularly dangerous when there is myocardial disease, and is apt to produce cyanosis and embarrassed respiration. In valvular heart disease chloroform is more dangerous than ether, and even in functional heart trouble it is an undesirable anesthetic. It should not be used in those who smoke or chew tobacco to excess, or who overindulge in coffee or alcohol. Chloroform is more dangerous in shock than ether. A patient in dangerous shock requiring operation should, if possible, have the nerves coming from the part injected with cocain so as to prevent shock by introducing a "physiological block" (Crile) (page 242). Chloroform is preferred for patients with difficult respiration from any cause other than heart disease, for patients with kidney disease, and for patients with diabetes. Some surgeons do not use ether in abdominal operations, because they believe it may cause persistent oozing of blood, but this view is not in accord with the author's experience. Ether is the best and safest anesthetic for general use. It is much safer than chloroform in valvular disease and functional heart trouble. It is dangerous in myocardial disease, but not nearly so dangerous as chloroform. In valvular disease without heightened arterial tension it is reasonably safe, but in valvular disease with heightened arterial tension it is dangerous. Ether is dangerous when atheroma exists. Both ether and chloroform may induce changes in the blood.* In practically all cases they produce a diminution of hemoglobin and leukocytosis. In some cases they produce alteration in the shape of the corpuscles. These changes are especially marked in anemic blood. Ether produces distinct leukocytosis, probably toxic in origin. These blood-changes indicate that prolonged anesthesia may militate against recovery from a severe operation. If a patient's hemoglobin is below 30 per cent., a general anesthetic should not be given. During the state of anesthesia the temperature drops from one to three degrees or more, hence the patient should be carefully covered during the operation. The question as to the effect of ether on the kidneys is much disputed. Most surgeons believe that it tends to cause albuminuria or increase existing albuminuria. Nitrous oxid is very dangerous when there is vascular degeneration, and it may induce apoplexy. In giving ether or chloroform the administrator must devote his undivided attention to the task. He must note every symptom, must order or carry out proper treatment for complications, and must keep the operator informed as to the necessity for haste. The anesthetist must be a man who has a wholesome respect for ether and chloroform, although not afraid of them.

Can an anesthetic be administered to a sleeping person without waking him? I know that chloroform can be so given, for I have succeeded in giving it to a child without breaking the slumber. Probably, in most cases, an attempt will fail, but in some it will succeed. Stone ("Cleveland Med. Jour.," Jan., 1902) reports successful administration to sleeping children

* See the author on the "Blood-alterations of Ether-anesthesia," Medical News, March 2, 1895, and also the author and Kalteyer in The Proceedings of the American Surgical Assoc. for 1901.

and also the chloroforming of a resident physician while asleep. Paugh ("Jour. Amer. Med. Assoc.," May 18, 1901) reports three successes with children. Ether, because of the irritant nature of its vapor, would be more apt to arouse a sleeper than would chloroform.

Administration of Chloroform.—Chloroform should be given only by a trained man. In fact, safety in giving chloroform is dependent upon skill and experience more than in giving ether. The most dangerous period is when the patient is incompletely anesthetized, but is going under. Most deaths happen at this time. In administering chloroform have at hand a mouth-gag, tongue forceps, artery forceps, small gauze sponges, a clean towel, a hypodermatic syringe, solutions of strychnin, atropin, and brandy, an electric battery, and a can of oxygen. Use only *pure* chloroform. The patient must be recumbent. No special inhaler is required, but the drug may be given upon a thin towel, a napkin, or a piece of lint. The mask of Skinner is very useful (Fig. 621). Junker's inhaler is used by many anesthetists (Fig. 620). In operations about the face Souchon's instrument is serviceable. Souchon's apparatus is so arranged that chloroform may

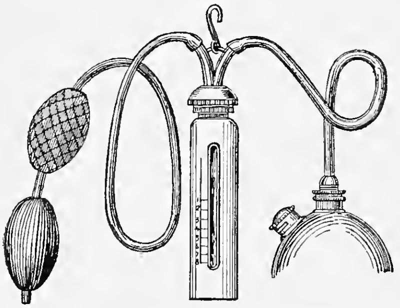


Fig. 620.—Junker's inhaler.

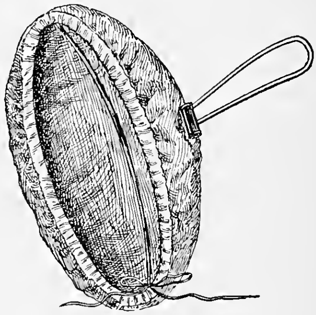


Fig. 621.—Skinner's mask.

be given through a tube which is introduced through the nose, the instrument being well out of the way of the operator. Some surgeons cocainize the nares before giving chloroform, so as to prevent the supposedly dangerous nasal reflex (Rosenberg). It is a good plan to smear the lips with cosmolin to prevent blistering. The chloroform-vapor must be well mixed with air. The chloroform is sprinkled on the fabric with a drop-bottle. Raise the napkin well above the mouth, add five drops of chloroform, and tell the patient to take deep and regular breaths, but do not tell him to breathe forcibly. Forcible respiration may lead to cessation of respiration. Add a few more drops of chloroform, and when the patient grows so accustomed to it that it does not choke, turn the wet part of the fabric toward the face and place it near the mouth; do not touch the mouth with the wet lint, because it will blister. If the drug is given *gradually*, struggling is not usually violent or prolonged. Never pour on a large amount at one time. Keep the lower jaw pushed forward during the time the chloroform is being given. Cough and vomiting at this time mean that the vapor is too strong. During the stage of excitement do not suspend the administration of chloroform unless respiration becomes difficult, in which case suspend it until the patient takes

one or two respirations. If the patient struggles, do not hold him and push the administration of the drug. He holds his breath while struggling, and as struggling ceases takes full, deep breaths. If the inhaler is saturated with chloroform, he may inhale a dangerous amount during the deep respiration after struggling. Chloroform given in considerable amount when the patient is breathing deeply from the effects of ether is unsafe. If chloroform is given subsequent to anesthetization by ether, it should be given gradually and well mixed with air. When the patient becomes anesthetized, give just enough of the drug to keep him so. After the patient has been anesthetized, hiccough usually means that vomiting is going to occur. If vomiting occurs at this time, more chloroform must be given to abolish the reflexes. Deep and sighing respiration and repeated swallowing indicate that more of the anesthetic is required. Stop the administration or give very little when shock becomes evident or when there is profuse hemorrhage. Chloroform-vapor is not inflammable, hence it is safer than ether when a hot iron is to be used about the face and when there is a lighted lamp or a stove in a small room; but the presence of a naked gas-flame decomposes chloroform into irritant products of chlorin, which sometimes cause the patient and the surgeon to cough ($COCl_3$).

Chloroform and Oxygen.—The use of this mixture was suggested by Neudorfer. Some anesthetists advocate the use of chloroform and oxygen, asserting that it does not produce spasm of the glottis or muscles of respiration, that it does not produce cyanosis or weakness of circulation, that it does not irritate the kidneys, is safer to life than pure chloroform, and is less often productive of severe and prolonged vomiting. These alleged advantages are probably stated with rather undue emphasis, although I do believe the mixture has less tendency to produce cyanosis than has the pure drug, does not so often induce vomiting, and is somewhat safer. Hewitt does not think that the method offers any "special advantages" ("Anesthetics and their Administration," by Fred. W. Hewitt). If this method is used, a bag containing oxygen is attached to the hand-bellows attachment of a Junker inhaler, and oxygen is forced through the chloroform and flows to the face-piece.

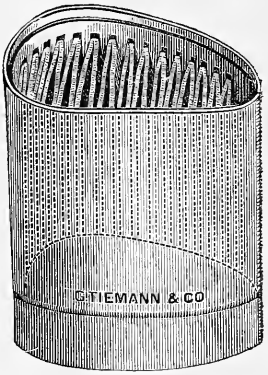


Fig. 622.—Allis's ether-inhaler.

Administration of Ether.—The administration should not be intrusted to a novice. The anesthetist should be one of your best men. Ether is best given by a partially open inhaler. The most satisfactory appliance is Allis's inhaler (Fig. 622). This inhaler secures a plentiful supply of air. Before being used, the metal frame is scalded, dried, and threaded with a clean gauze bandage. The end of the frame which is to be toward the mouth is covered with one layer of gauze. The frame is then inserted in a clean metal case and the case is wrapped in a clean towel. Many surgeons prefer closed inhalers. The Clover inhaler is popular in England (Fig. 623). *F* is the face-piece; *C*, a reservoir of ether through which the air-current passes; *B* is an India-rubber bag. In this apparatus there is

no provision for the entrance of fresh air. By turning the reservoir *C* on the tube *t* the amount of current passing over the ether can be regulated. When this apparatus is used, the ether-vapor breathed into the lungs is expired into the bag and is rebreathed. This inhaler, if used by a skilful man, is very useful; but any lack of watchfulness or skill will permit of cyanosis, and the very young, the senile, the anemic, and feeble are best anesthetized by the Allis inhaler.

An admirable detailed account of anesthetization by the closed method will be found in Mr. Frederic W. Hewitt's treatise on "Anesthetics and their Administration" (page 272), and in Mr. Dudley W. Buxton's treatise on "Anesthetics, their Uses and Administration" (page 109). When giving ether, have at hand the same drugs and appliances as when chloroform is given, and keep the lower jaw pushed forward during the administration. When anesthetizing by Allis's inhaler, place the dry inhaler over the mouth and

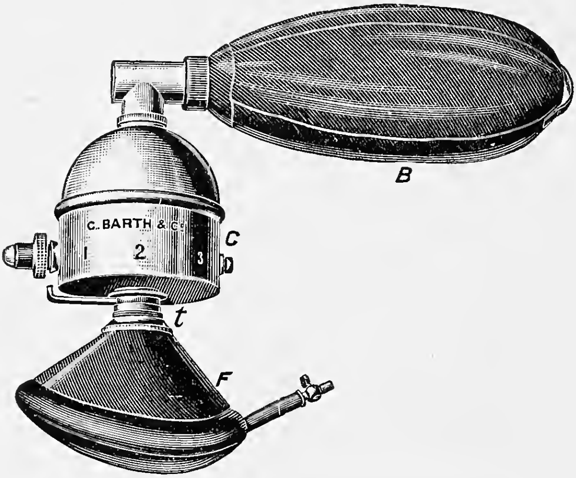


Fig. 623.—Clover's portable regulating ether-inhaler.

nose, let the patient take several breaths that he may gain confidence, pour a few drops of ether into the inhaler, let the patient take several more breaths, and so on, gradually increasing the amount of ether. If he tends to struggle, diminish the amount of ether for a time, but do not hold him. Do not tell him to breathe forcibly. Forcible breathing is liable to cause cessation of respiration. Never suddenly add a large amount of the anesthetic: it causes coughing and often vomiting. When the patient becomes thoroughly anesthetized, give a very little ether as often as is required to maintain unconsciousness. When bleeding is profuse or shock is marked, suspend the administration of ether or give very little of it. If a hot iron is to be used about the face, remove the inhaler and fan away the ether before bringing the cautery near. Have any light set high up, as ether-vapor is heavier than air, and no explosion is possible until it reaches the level of the flame. If the vapor takes fire, cover the patient's mouth and nose with a towel. If he rolls his eyes from side to side, if the respirations are deep and sighing, if there are repeated movements of swallowing,

more anesthetic should be given (Tarnowsky). Hiccough is often preliminary to vomiting, and always means that the reflexes are returning.

Ether and Oxygen.—This mixture is useful in certain cases in which respiratory difficulty exists, particularly in empyema. If during the administration of ether cyanosis tends to occur, it is often advantageous to give oxygen with the ether. The process of anesthetization by ether and oxygen is somewhat slower than by ether-vapor mixed with air. It can be given by inserting beneath the Allis inhaler or pushing deep down into it, from above, a tube attached to a reservoir of oxygen and from which a stream of oxygen emerges.

Rectal Etherization.—Roux suggested this method in 1847. A bottle of ether is set in water at a temperature of 122° and a rubber tube connected with the bottle is inserted in the rectum (Mollière, in "Lyon Médical," April 28, 1884). The method has never come into general use. It irritates the large intestine, and sometimes is said to lead to protracted stupor ("Anesthetics and their Administration," by Fred. W. Hewitt). Dudley W. Buxton, however, has employed it in many operations about the face, mouth, and larynx, and in some operations for empyema, and commends it.

Anesthetic State from Ether or Chloroform.—The inhalation of an anesthetic produces irritation of the fauces, often some cough, a profuse secretion of mucus, acts of swallowing, dilatation of the pupils, flushed face, and sometimes struggling (especially in children and in drunkards). If the vapor is given at once in concentrated form, cough will be violent and will cause cyanosis. If the anesthetic is given carefully, the cough soon ceases, the respirations become rapid and often convulsive, the pulse becomes frequent, and the patient passes into a condition of active intoxication with preservation of sight and touch, loss of hearing and smell, diminution of pain and sensibility, and often with illusions or hallucinations. In this stage the patient may struggle, and while efforts are being made to hold him, cyanosis may occur. From the stage of excitement just alluded to, many subjects (strong men and drunkards) pass into a stage of rigidity in which the muscles become firmly fixed, the breathing impeded, the respirations stertorous, and the face bluish and congested. Too rapid forcing of the anesthetic tends to cause rigidity, and a skilled anesthetist endeavors to avoid its production, because it is dangerous. The next stage is one of insensibility; the pupils are contracted, but react to light. If anesthesia is deep, the contracted pupils will not react to light; if anesthesia is profound, the pupils dilate, but will not react to light. The conjunctival reflex is gone; the lids are closed; if the arm is lifted and allowed to fall, it drops as a dead weight; the skin is cool and moist, and often wet with sweat; the respirations are easy and shallow; the pulse is slow; and there is complete unconsciousness to pain. The loss of conjunctival reflex is the usually accepted sign that the patient is unconscious. In a young child this reflex is soon exhausted by touching the eye, and the sign is unreliable. If a baby is to be anesthetized, the administrator places his finger in the infant's hand. The child grasps the finger, and relaxes its grasp when unconscious.

Always bear in mind that a dilated pupil reacting to light and associated with preserved conjunctival reflex means that anesthesia is not complete; that a contracted pupil reacting to light and without conjunctival reflex

means moderate anesthesia; that a contracted pupil not reacting to light and without conjunctival reflex means deep anesthesia; that a dilated pupil not reacting to light and associated with lost conjunctival reflex means dangerously profound anesthesia; that weak pulse and pallor may be due to nausea, but always require instant attention; that vomiting may be due to forcing strong vapor upon the patient, but that it may also be due to his partially emerging from a state of insensibility.

Watch the pulse carefully to see if it becomes very weak, irregular, abnormally slow, or abnormally fast. Syncope may be due to nausea, shock, hemorrhage, or the giving of too much of the drug. Watch the respiration, and do not forget that the chest-walls and belly may move when no air is entering the lungs; hence always *listen* to the breathing. *Cyanosis* is a dusky or bluish discoloration of the skin. This condition indicates want of oxygen in the blood. The individual may have been cyanotic or predisposed to cyanosis to start with; cyanosis may be due to posture; to cough early in the administration; to struggling during the stage of excitement; or to rigid fixation of the respiratory muscles. It may also be due to obstruction of the air-passage by some foreign matter, as blood or vomit, lodging in the bronchial tubes, windpipe, larynx, or pharynx; falling back of the tongue (*swallowing of the tongue*); closure of the epiglottis; or to the glottis being pushed against the pharyngeal wall by bending the head forward. Some patients with occluded nostrils may fail to get enough air because of closure of the lips. A patient may, while taking an anesthetic, lie perfectly quiet and appear to "forget to breathe." Shock is manifested by deathly pallor, weak, rapid, and irregular pulse, slow respiration, cold extremities, and a drenching sweat. Edema of the lungs occasionally arises during or after anesthesia.

Treatment of Complications.—*Vomiting* due to too much anesthetic is corrected by giving a few breaths of air; vomiting due to incomplete anesthesia is amended by giving more of the vapor. When the patient vomits, hold the head over the edge of the bed, separate the jaws with the gag, and wipe out the vomited matter, mucus, and saliva. *Shock* is treated by diminishing the amount of the anesthetic given, by the hypodermatic injection of atropin (atropin is very useful when there is a profuse sweat), by the administration of hot saline fluid by the rectum, by surrounding the patient with hot-water bottles, or by wrapping him in hot blankets, and by lowering the head of the bed. A tendency to *syncope* requires lowering of the head of the bed, suspension of the anesthetic, and hypodermatic injection of strychnin. In *extreme syncope*, which is most apt to occur from chloroform, do not wait for breathing to cease, but suspend the anesthetic, lower the head of the bed, open the mouth with the gag, catch the tongue, and make rhythmical traction while an assistant is making *slow* artificial respiration. If the patient does not *at once* improve, invert him completely, holding him by the legs and continuing artificial respiration by compressing the sternum (Nélaton). By continuing artificial respiration the blood is urged on through the heart. Give hypodermatic injections of atropin, ether, or even of ammonia. Put mustard over the heart and spine. Employ faradism to the phrenic nerve (one pole to the epigastric region, the other to the right side of the root of the neck). Let fresh air into the room, put hot-water bottles around the legs, apply friction to the extremities, wrap the patient

in hot blankets, give an enema of hot salt solution, and hold ammonia to the nose. In some cases of chloroform poisoning *direct heart massage* has been successfully employed. In Sencert's successful case an operation was being done for gall-stones when collapse occurred, and the surgeon stroked and kneaded the heart through the diaphragm. In a case recorded in the "Brit. Med. Jour.," Nov. 18, 1905, respiration and pulse had ceased three minutes when the abdomen was opened and the heart was kneaded. Recovery ensued. Müller, of Hamburg, advocates exposing and opening the pericardium to perform massage, introducing oxygenated salt solution into a vein, opening the trachea, and performing artificial respiration. Leonard Hill holds that in the failure which arises soon after administration of chloroform is begun the trouble is due to vasomotor paralysis with starvation of the nerve-centers. In such a case he applies abdominal compression and inverts the patient, making artificial respiration at the same time. In the failure which occurs after *considerable chloroform has been taken* there are paralytic distention of the heart, fulness of the venous system, and loss of the compensations for the hydrostatic effects of gravity. In such a condition empty the distended heart of venous blood by raising the patient into an erect position; and after a moment place him recumbent and make artificial respiration.

"*Forgetting to breathe*" is met by removing the inhaler and waiting a moment; a breath will usually be taken soon; but if it is not taken, somewhat forcibly knead the structures in the arm-pit. If this fails, open the mouth and pull forward the tongue; this causes a reflex inspiration. Cyanosis is practically not encountered when oxygen is given with ether or chloroform. *Cyanosis*, if slight, and due to cough or struggling, is met by removing the inhaler while the patient takes a breath or two of air. If position is responsible for cyanosis, correct it. In empyema, lying upon the sound side may produce it, and obstruction to breathing may be due to bending down the head. If due to stenosis of the nares in a person without teeth, hold the lips apart with a finger.

Dudley W. Buxton points out that duskiness will often pass away if ether is removed, one or two inhalations of chloroform given, and ether then continued. If in any case cyanosis is severe or grows worse, suspend the drug, dash cold water in the face, force open the jaws, pull forward the tongue, make artificial respiration until a breath is taken, and then give oxygen for a time. If these means fail, stretch the sphincter ani and bleed from the external jugular vein. If a breath is not now taken, do tracheotomy. In respiratory or heart failure forced artificial respiration by Fell's method is of great value (page 777). In Fell's method a tracheal tube is inserted, and by means of a foot-bellows air is forced into the lungs, after first passing through a warming chamber. Instead of a tracheal tube, we may use a face-mask and an intubation-tube. "*Swallowing the tongue*" is corrected by pulling the tongue forward. If it tends to recur, lay the head upon its side or keep the tongue anchored with forceps. *Closure of the epiglottis* is corrected by pulling the patient's head over the edge of the table and pushing strongly back upon his forehead. This maneuver lifts the hyoid bone, and with it the epiglottis. The epiglottis can be lifted by passing a spoon-handle or the index-finger over the dorsum to the base of the tongue and press-

ing forward. If, in obstruction to respiration, the above means fail, make artificial respiration at once; if obstruction continues, perform tracheotomy.

Edema of the lungs is treated by instant venesection, the inhalation of nitrite of amyl, and the administration of stimulants and nitroglycerin hypodermatically. Sometimes, duing the anesthetic state, the muscles of the belly become very *rigid*, a condition which greatly interferes with an abdominal operation. It may arise during cyanosis, and if so caused, is amended, as cyanosis abates, under proper treatment. In some cases it is due to the fact that sufficient anesthetic has not been given. If the air-passages are

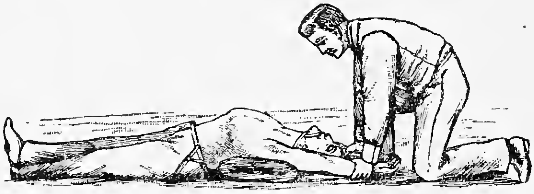


Fig. 624.—Artificial respiration, first movement.

obstructed, abdominal rigidity is apt to arise. In some cases it seems impossible to overcome it with ether. In such a case, if the anesthetist is a trusted man, anesthetize the patient with gas and ether and then give chloroform (Blumfield, in "Lancet," May 31, 1902).

Artificial Respiration.—Laborde's Method.—Place the patient on his back with the head lower than the body, all the clothing loosened, and the jaws wedged apart, and wipe the mucus from the throat and mouth. Grasp the tongue with forceps, and once in every four seconds pull it quickly and strongly forward and then permit it to go back. It may be necessary to keep up this proceeding for thirty minutes or even more.

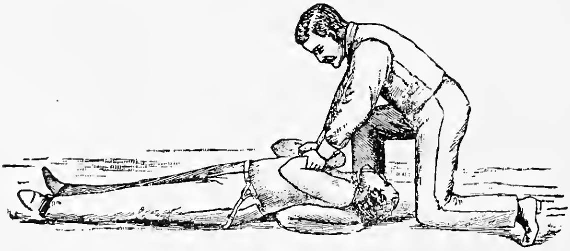


Fig. 625.—Artificial respiration, second movement.

Laborde's method should be associated with "concentric thoracic and upward abdominal pressure applied in a rhythmic manner by two assistants at the time of relaxation of the tongue."* Laborde believes that tongue-traction causes contractions of the diaphragm.

Sylvester's Method (Figs. 624, 625).—The patient is placed recumbent with the foot of the bed raised. The surgeon grasps the arms just above the elbows, and draws them outward and upward until they are nearly per-

*Joseph D. Bryant's "Operative Surgery."

pendicular (Fig. 624); they are held perpendicular for two seconds, while air is entering the lungs; the arms are then lowered and pressed against the sides of the chest (Fig. 625) for two seconds, during which time the chest is emptied as in expiration. These movements of elevation and depression are made twelve or fifteen times a minute.

The Reaction from Anesthesia.—When ether or chloroform is given, a considerable quantity is swallowed and either drug irritates the stomach and creates nausea and often vomiting. The longer the operation, the more of the anesthetic enters the stomach, and the greater the liability to subsequent vomiting. At the termination of a prolonged operation upon an adult, if the patient's condition admits of it, and if the nature of the operation does not forbid it, I like to have a stomach-tube passed and the stomach well washed out with warm water. The washings smell strongly of the anesthetic, and the procedure greatly lessens the severity and frequency of post-operative vomiting (Geo. S. Brown, in "Surgery, Gynecology, and Obstetrics," August, 1905). After the administration of the anesthetic has been suspended and the operation has been completed, the temperature is usually subnormal. The patient must be watched until consciousness returns. If he is left alone, a change of posture may lead to arrest of feeble respiration, the assumption of the erect position may cause fatal syncope, or mucus or vomited matter may block the air-passages and cause suffocation. The best position to place him in is the recumbent, the head being level with the body or somewhat lower, and the side of the face resting on the pillow. Shock is treated by ordinary methods. The inhalation of oxygen is of great value in rousing a patient from the state of anesthesia, and will often prevent vomiting. If vomiting occurs, the head should be upon its side or should be held over the edge of the bed, and after the spell of vomiting the mouth must be wiped clean. The face should be washed with cold water and be fanned rather actively. It is the routine practice of some surgeons to administer vinegar by inhalation during the reaction from an anesthetic. This proceeding sometimes seems to prevent vomiting. Some patients awake from anesthesia as from a quiet sleep; others are noisy, turbulent, and violent. The duration of the period of reaction varies with the anesthetic used, the amount given, and the personal tendencies of the patient. The patient must not be allowed to sit up for several hours at least. No food is to be allowed for at least six hours. Unless the operation was upon the stomach, I do not forbid water, but allow the patient to drink freely of hot water. This dilutes any irritant material in the stomach and dissolves mucus, and if vomiting does occur, it serves to wash the stomach out.

After-effects of Anesthetics.—Vomiting.—Vomiting may occur in spite of all we can do, and may persist for hours, greatly exhausting the patient and doing infinite harm, it may be, if the operation were upon the brain or an intra-abdominal structure. If vomiting continues, forbid food. Very hot water in doses of a teaspoonful should be given at frequent intervals. A draught of hot water may relieve the condition by washing out the mucus from the stomach. Other remedies which may succeed are: inhalations of vinegar, hot black coffee by the mouth, a mustard plaster over the stomach, fresh air in the room, small pieces of ice placed in the mouth and sucked, small doses of iced champagne, and drop doses of a 3 per cent. solution of cocain or

3-drop doses of a 5 per cent. solution of eucain. The best remedy for persistent vomiting is lavage of the stomach. Some persons, as Dudley W. Buxton points out, suffer greatly from nausea, although there is little or no vomiting. In such cases Buxton uses ♏j of tincture of nux vomica in a teaspoonful of hot water every ten minutes until six doses are taken. If this plan fails, he gives drop doses of wine of ipecac or minim doses of dilute hydrocyanic acid.*

Vomiting from chloroform is usually more difficult to check than vomiting from ether.

Respiratory disorders are more often noted after ether than after chloroform. Bronchitis may follow or bronchopneumonia (*ether-pneumonia*). Respiratory difficulties may be due to chilling the patient by bringing him from a warm operating-room through a cold hall and into a cool bedroom. Bronchopneumonia is especially common in septic patients, and may be due in some cases to septic emboli and in others to aspiration of septic material into the bronchi (cases of cancer of tongue and pharynx, and cases with stercoraceous vomiting). They are treated by ordinary methods. If chloroform is given when a gas-light is in the room, the vapor is decomposed and certain highly irritant products are formed, which, when inhaled, produce laryngeal spasm and possibly bronchitis. The irritant material is probably $COCl_3$. The treatment is freely to admit fresh air into the room, and to have the patient inhale oxygen or vinegar. Ether-pneumonia must not be confounded with post-operative pneumonia, described by Wm. H. Bennett.† This latter condition may arise from seven to fourteen days after operation in robust, gouty people, and is usually unilateral.

Renal Complications.—After the administration of an anesthetic, blood, albumin, or sugar may appear in the urine, and the secretion may become scanty or even be suppressed. It is usually maintained that chloroform is less apt to irritate the kidney epithelium than is ether, but there has been much dispute on this point. If casts and albumin are present before anesthetization, the condition may be rendered worse when ether or chloroform is given. If neither casts nor albumin are present, they will not be so apt to appear after taking chloroform as after taking ether, but if they do appear after chloroform, they remain longer than after ether (Legrain). The truth of the matter probably is that if the kidneys are healthy, a small or moderate amount of either drug is not particularly irritant; but if the kidneys are diseased, a small amount, and even if they are healthy, a large amount, of either drug produces decided renal irritation. Chloroform is less irritant because less chloroform than ether is given to secure and maintain anesthesia. Scantiness or suppression of urine may be due to operative shock rather than to ether or chloroform. If the urine becomes somewhat scanty or if albumin appears in it, give non-irritant diuretics, diaphoretics, and cathartics, and employ enteroclysis. If the urine becomes very scanty, use hypodermoclysis. If post-operative suppression arises, it is the usual custom to give intravenous infusion of hot saline fluid, but I am doubtful of its value. Exposure of each kidney in the loin and incision of its capsule to relieve tension is justifiable and may do good.

* "Anesthetics," by Dudley W. Buxton.
† Practitioner, Dec., 1896.

Acid Intoxication.—This condition has been called "*delayed poisoning*," *acetonuria*, and *acidosis*. It is known that even in healthy urine there may be a trace, but a bare trace, of acetone. In certain cases in which dangerous symptoms arise after anesthesia, the urine contains albumin, casts, and either diacetic acid or acetone or both of these substances. Acid intoxication is much commoner after the administration of chloroform than of ether, but may follow the giving of any general anesthetic. It may occur in individuals whose tissues contain areas of fatty degeneration, but it also occurs in those entirely free from degeneration; in fact, children particularly suffer in this way after the use of chloroform. The actual operation has nothing to do with the trouble, and sepsis is not causative. The drug used as an anesthetic breaks up fat and forms certain antecedents or precursors of acetone; these precursors are β-oxybutyric and other acids (Guthrie). The symptoms arise after the patient has emerged from anesthesia and reacted from shock. There is persistent vomiting of thin and foul fluid, the patient is extremely restless and much excited, there may be delirium, but dulness and heaviness may take the place of restlessness and excitement and coma may arise (J. A. Kelly, in "Annals of Surg.," Feb., 1905). Usually the temperature is subnormal, but sometimes there is elevated temperature. In many cases jaundice arises There is an odor of acetone on the breath. The urine contains albumin and casts, and either diacetic acid or acetone or both. Some cases recover, but most of them die in from one to five days. A knowledge of this condition explains some otherwise inexplicable deaths, and also some cases of retarded convalescence. In acid intoxication there is fatty degeneration of the kidneys, of the liver, of the suprarenal glands, and of the gastric mucosa. The occurrence of such a condition is an impressive admonition that a surgeon should operate quickly, that as little of the anesthetic should be given as possible, and that the urine should be carefully examined each day after operation for certainly several days. Severe acid intoxication is treated as follows: Encourage skin activity by wrapping the patient in blankets and surrounding him with hot-water bags. Give salt solution with bicarbonate of sodium by hypodermoclysis and by the rectum. In mild cases of acetonuria simply give sodium bicarbonate by the stomach. (On this subject see Lewis Beesly, in "Brit. Med. Jour.," May 19, 1906; J. A. Kelly, in "Annals of Surgery," Feb., 1905; A. D. Bevan and H. B. Farill, in "Jour. Am. Med. Assoc.," Sept. 20, 1905; Geo. E. Brewer, in "Transactions Am. Surg. Assoc.," vol. xx, 1902.)

Post-anesthetic Paralysis.—Paralysis may arise during anesthesia as a result of cerebral hemorrhage or embolism.

It sometimes happens that when a person has come out of anesthesia a palsy of some part is found to exist, the condition being peripheral and not central in origin. Such palsies may be due to pressure of an extremity upon a table-edge or to pressure upon nerves by placing the patient in certain positions.* Garrigues points out that when the arm is elevated to the side of the head or when it is drawn out strongly from the body the brachial plexus may be compressed by the head of the humerus (Braun). When the arm is in external rotation and is drawn backward and outward, the median nerve is stretched, and when the forearm is flexed and supinated,

* H. J. Garrigues, in Amer. Jour. Med. Sciences, Jan., 1897.

the ulnar nerve is stretched (Braun, quoted by Garrigues). Garrigues insists that in most cases the brachial plexus is squeezed between the collar-bone and the first rib, and it is particularly apt to be squeezed when it is stretched by the head being drawn to the opposite side or being allowed to fall back.*

Post-anesthetic paralysis is most common in the arm, but may occur in the leg or face. The prognosis is good as a rule. The treatment is that of any pressure palsy.

Primary Anesthesia.—Instruct the patient to count aloud and hold one arm above his head. Give the ether rapidly. In a short time he becomes mixed in his count and his arm sways or drops to the side. There is now a period of insensibility to pain lasting only about half a minute, and during this period a minor operation can be performed. The patient quickly reacts from primary anesthesia without vomiting (Packard).

Mixtures.—Mixture of Ether and Chloroform.—This may be used in varying proportions. Hewitt employs 2 parts of chloroform to 3 parts of ether.

Mixture of Alcohol and Chloroform.—All the chloroform mixtures produce the effects of chloroform, but we are giving the drug in an unknown amount. It was believed by Sansom, who devised this mixture, that the alcohol prevents concentration of chloroform-vapor by retarding evaporation. When used, 1 part of alcohol is added to 4 parts of chloroform.

Nitrous Oxid and Oxygen.—(See page 1042.)

A. C. E. Mixture.—This mixture is often valuable in cases in which ether cannot be given. It is composed of 1 part of alcohol, 2 parts of chloroform, and 3 parts of ether. Its action is supposed to be between that of chloroform and ether. The objection to the A. C. E. mixture, as to any mixture, is that the materials do not evaporate in the ratio in which they are mixed, hence an uncertain amount of chloroform-vapor is being inhaled (Buxton). This mixture is given by some in a Junker and by others in an open inhaler. Plenty of air should be given with it. The anesthetic acts similarly to chloroform.

Schleich's Mixture for General Anesthesia.—Schleich has recently introduced *a new anesthetic agent* which he claims is safer than chloroform. This surgeon maintains that a material is safe as an anesthetic only when almost all of the amount taken in at an inspiration is expelled on expiration. The anesthetic is unsafe in direct proportion to the amount absorbed; and the lower the boiling-point of an anesthetic, the less is absorbed, hence an anesthetic agent, to be safe, should have a low boiling-point. Schleich makes three solutions. The first contains (by volume) $1\frac{1}{2}$ oz. of chloroform, $\frac{1}{2}$ oz. of petroleum ether, and 6 oz. of sulphuric ether. The second contains $1\frac{1}{2}$ oz. of chloroform, $\frac{1}{2}$ oz. of petroleum ether, and 5 oz. of sulphuric ether. The third contains 1 oz. of chloroform, $\frac{1}{2}$ oz. of petroleum ether, and $2\frac{2}{3}$ oz. of sulphuric ether. The anesthetic can be given on an open inhaler or a towel. The anesthetic state is quiet, reaction is rapid, and vomiting occurs in but half the cases. The superiority of this new anesthetic has not been proved. It sometimes causes dangerous symptoms, and has produced death. Garrigues, who formerly approved of it, has abandoned it. It will certainly not displace ether or chloroform.

* Amer. Jour. Med. Sciences, Jan., 1897.

Ethyl bromid is sometimes used for short operations. It is given while the patient is recumbent. The unconsciousness is obtained in from one to three minutes and is rapidly recovered from, and there is no after-sickness. The unconsciousness lasts about three minutes. Three drams are given to a child, and six drams to an adult. A towel is put over the face, and the entire amount to be given is poured on at once, and as soon as the patient is unconscious the towel is taken away and no more of the drug is given (Cumston). Even if consciousness is regained too quickly to suit the purposes of the surgeon, it is not safe to give more of the drug, a notable objection which chlorid of ethyl does not possess. Cases have been reported in which sudden death has followed the administration of this drug, and it should not be given if there is disease of the heart, lungs, or kidneys.* Twenty-four deaths from bromid of ethyl are on record (Gaudiana). If it kills, it acts like chloroform. It may be given *before* ether to prevent unpleasant effects, but it is usually not considered proper to give it before chloroform. Zematski, however, has used it before chloroform in 2000 cases ("Vratch," August 25, 1901).

Chlorid of ethyl is a rapid anesthetic and appears to be a safe one. It was first used by Heyfelder in 1848. A committee of the British Medical Association condemned it in 1880. Carlson and Thiesing reintroduced it in 1895 (McCardie, in "Lancet," April 4, 1903). It should be given upon a mask so that it does not evaporate into the air. The odor of the drug is agreeable. From 8 to 10 gm. of ethyl chlorid are given for a short operation. The patient must always be recumbent when taking it. The anesthetic state is induced in from thirty seconds to three minutes, and as soon as it is obtained the patient is allowed to get air. The anesthetic condition lasts from one to three minutes, and it is recovered from rapidly, usually without vomiting or unpleasant after-effects. If the patient recovers too rapidly for the surgeon's purpose, more ethyl chlorid can be given. It is to be noted that complete muscular relaxation does not occur, in many cases the conjunctival reflex is not completely abolished, and often the pupils do not dilate. Its superiority over nitrous oxid, except as to cost and portability, is doubtful, and sometimes it fails to produce complete unconsciousness. A large dose rapidly given is dangerous, as it may cause cessation of respiration and spasm of the diaphragm. A contraindication to its use is any respiratory obstruction. Concentrated vapor administered for a considerable time lowers the blood-pressure, induces cyanosis and asphyxia, and would eventually cause death by respiratory failure (McCardie, in "Lancet," April 4, 1903). Lotheisser, in a study of 2500 cases of anesthesia by this agent, reports 1 death. Ware collected 12,436 cases with 1 death ("Jour. Am. Med. Assoc.," Nov. 8, 1902). Seitz, of Konstanz, collected 16,000 cases with 1 death. It is safer than chloroform, not so safe as nitrous oxid, and not quite so safe as ether. The drug is used only for a brief operation or examination. It can be given to infants a few days old with safety and it has been administered many times to the aged. When it kills, it acts in a similar manner to chloroform. I often give it *before* ether to prevent unpleasant symptoms and to hasten the advent of anesthesia, but it must *never* be given before chloroform.

Nitrous oxid gas may be used to obtain anesthesia for brief operations.

* See Cumston, in Boston Med. and Surg. Jour., Dec. 20, 1894.

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It is contraindicated when vascular degeneration exists, because apoplexy may follow its administration. This gas is stored in steel cylinders, in which it is liquefied. The gas is passed into a rubber bag (Fig. 626), and is given to the patient by means of a tube and a mouth-mask, a wedge being placed between the patient's molar teeth, and the nostrils being closed by the anesthetist's fingers. The wedge must be held by a string, so that it cannot be swallowed. The patient becomes unconscious in about one minute, and we know the patient is anesthetized by the stertor and cyanosis and the insensitiveness of the conjunctivæ. Watch the pulse, and if it flags, at once suspend the administration. The phenomena are asphyxial, stertorous respiration, cyanosis, and even convulsions, dilatation of the pupils, rapidity of the heart, and swelling of the tongue.* It is sometimes useful to give nitrous oxid first and follow this with ether (page 1044). By this method the patient is anesthetized rapidly and pleasantly with the nitrous oxid, and the anesthesia is maintained by the ether.

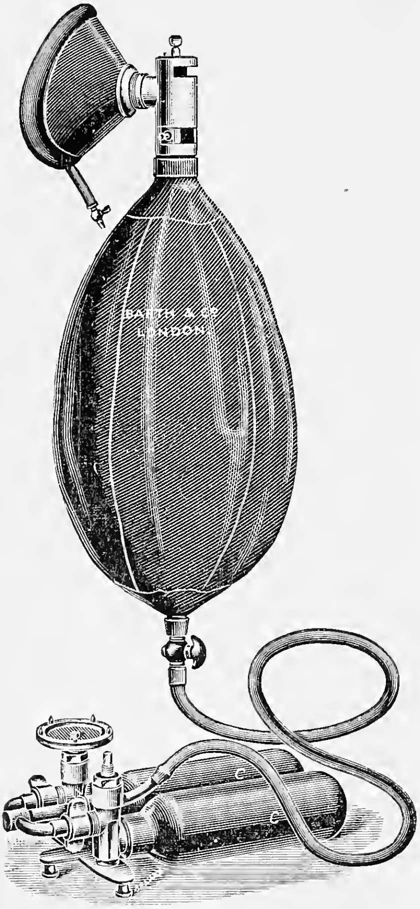


Fig. 626.—Hewitt's nitrous oxid apparatus.

It was formerly taught that nitrous oxid necessarily produces cyanosis, because the gas can only cause anesthesia by partially asphyxiating the patient. We know this is untrue, because if nitrous oxid is mixed with oxygen or atmospheric air anesthesia is obtained without cyanosis. Nitrous oxid is a genuine anesthetic agent. If a prolonged administration of nitrous oxid is desired, pure nitrous oxid can be given, a breath of fresh air being allowed from time to time. By this method Preston has anesthetized many patients, the duration of the anesthesia being from ten to fifty minutes. A better plan is to give nitrous oxid and oxygen. Hewitt formulates the following views as to the use of oxygen and nitrous oxid:†

"In order to obtain the best form of anesthesia oxygen should be administered with nitrous oxid by means of a regulating apparatus (Fig. 627), the percentage of the former gas being progressively increased from 2 to 3 per cent. at the commencement of the administration to 7, 8, 9, or 10 per

* See Hewitt, Brit. Med. Jour., Feb. 18, 1899.
† Brit. Med. Jour., Feb. 18, 1899.

cent., according to the circumstances of the case. The longer the administration lasts, the greater may be the percentage of oxygen admitted.

"The next best results to those obtainable by means of a regulating apparatus for nitrous oxid and oxygen are to be secured by administering certain constant mixtures of these two gases. Mixtures containing 5, 6, or 7 per cent. of oxgyen are best for adult males; and mixtures containing 7, 8, or 9 per cent. are best for females and children. The next best results

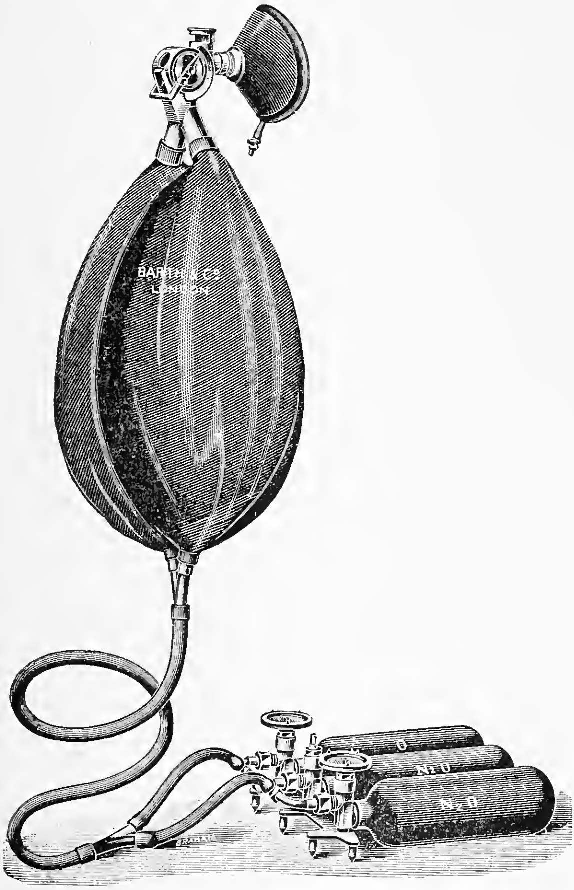


Fig. 627.—Hewitt's nitrous oxid and oxygen apparatus.

to those last mentioned are to be obtained by means of mixtures of nitrous oxid and air, from 14 to 18 per cent. of the latter being advisable in anesthetizing men, and from 18 to 22 per cent. in anesthetizing women and children."

Bichlorid of Methylene.—The composition of the so-called bichlorid of methylene is a matter of dispute. Some high authorities believe it to be a mixture of methyl alcohol and chloroform. It rapidly produces unconsciousness, and the patient returns quickly to consciousness when the ad-

ministration is suspended. Some surgeons have thought highly of it, and claim that it is pleasant, safe, and is not followed by vomiting as often as is chloroform. The weight of opinion is that it is dangerous, death being similar to death from chloroform. It is given by means of a Junker apparatus.

Anesthetic Successions.—Bromid of Ethyl Followed by Chloroform or Ether.—(See page 1041.)

Chlorid of Ethyl Followed by Ether.—(See page 1041.)

Chloroform Followed by Ether.—Chloroform is sometimes given until the sensation becomes more or less obtunded, when ether is substituted. This is done to save the patient from the unpleasant sensations of etherization. It is a practice not to be commended, because it is precisely in the beginning that chloroformization is most dangerous.

Ether Followed by Chloroform.—When the patient cannot be relaxed or rendered unconscious by ether, or when some other complication develops, it is common practice to suspend ether and substitute chloroform. If the change is made, chloroform should be given cautiously. A large quantity should never be poured upon the inhaler at one time. The change should never be made when the patient is struggling, because the deep respirations which attend or follow struggling may lead to the rapid inhalation of a dangerous dose of chloroform-vapor. Further, as Hewitt points out, when the patient is deeply under the influence of ether, the change should not be made unless it is imperatively necessary.

Nitrous Oxid Gas Followed by Ether (Gas and Ether).—This very valuable method was suggested by Clover. I have used it repeatedly with great satisfaction. The patient is *made* unconscious by nitrous oxid and is *kept* unconscious by ether. Thus are avoided excitement, struggling, and the very unpleasant sensations induced by ether. More important even than this, the method is safe. It is more satisfactory in women and children than in men. In very muscular men and in very stout elderly men it should not be used. Many operators first anesthetize with nitrous oxid, using an ordinary dental apparatus, and then give ether on an ordinary inhaler. The anesthetist must bear in mind that ether must be given gradually, not suddenly poured on in large amount. Others prefer to use a combined gas-and-ether inhaler. Hewitt thus describes the administration by means of Clover's portable ether-inhaler fitted with a stop-cock and a detachable gas-bag ("Anesthetics and their Administration"):

"If the patient be lying upon his back, his head should be turned to one side. The face-piece with the charged ether chamber is then applied during an expiration. Air will be breathed backward and forward. When the respiration is seen to be proceeding freely, and the face-piece fits well, the charged gas-bag is attached to the ether chamber. Air will still be breathed, but not through the valves of the special stop-cock. When the valves are heard to be working properly, 'gas' is turned on, and is likewise breathed through the valves. Three or four respirations (or about one-half of the contents of the bag) are allowed to escape. The valve action is now stopped by turning the tap at the upper part of the stop-cock. At the same moment at which the patient begins to breathe 'gas' backward and forward, the rotation of the ether chambers, for the addition of ether-vapor

should be commenced. The administrator will, in fact, find that he can, in a few seconds from the commencement of the administration, rotate the ether chamber as far as '1' or '1½.' Should swallowing or coughing arise, he must rotate more slowly. Respiration soon becomes deep and regular, and more and more ether may be admitted. At about this juncture, if the apparatus has been fitting the face well, signs of nitrous oxid narcosis may appear, especially in those who are quickly affected by this gas. Should jerky breathing or 'jactitation' arise, one full inspiration of air may be admitted at the air-tap. It should be remembered, however, that in giving 'gas and ether' by this method, the object is to just steer clear of the clonus and 'stertor' of nitrous oxid narcosis, and to gradually but increasingly mix ether with the gas.

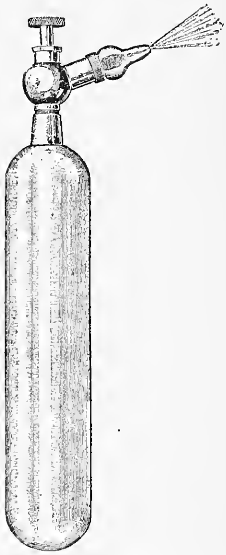


Fig. 628.—Gebauer's ethyl-chlorid tube.

"In muscular and vigorous subjects, the quantity of gas above mentioned will be found to be, as a general rule, insufficient to lead to the usual signs of deep nitrous oxid anesthesia. The rotation of the ether chamber should be continued till the indicator points to '2,' '3,' or 'F.'

"The mistake that is most commonly made is that of admitting air too soon. Should air be given during the first half or three-quarters of a minute, the patient will partially come round, hold his breath, set his teeth, and give a good deal of trouble. Duskiness of the features must be expected. Speaking generally, air should not be allowed until the patient is stertorous, when one breath may be given. In this manner the patient will continue breathing a mixture of nitrous oxid, ether, and air, till the usual signs of deep ether anesthesia appear, when the gas-bag may be detached, and the little bag ordinarily used with Clover's inhaler substituted."

Hewitt prefers to use a modified Clover's inhaler, which permits of the introduction of ether after the inhalation of nitrous oxid has begun.

Scopolamin-morphin Anesthesia.—This method has been enthusiastically praised and I used it with satisfaction in a number of cases, but I have grown afraid of it. In a patient in the Jefferson Hospital dangerous symptoms arose after a dose of gr. $\frac{1}{100}$ of scopolamin. Ely records a death from respiratory failure two hours after the administration of gr. $\frac{1}{8}$ of morphin and gr. $\frac{1}{100}$ of scopolamin ("New York Med. Jour.," Oct. 20, 1906). Fifteen deaths have been reported as following its use and there are beyond doubt unreported cases. Four deaths in 2400 cases were certainly directly due to it (H. J. Whitacre, in "New York Med. Jour.," March 31, 1906). It has even been stated that the death-rate is 1 in 100 ("Semaine Medicale," Jan. 11, 1905). Scopolamin is chemically identical with hyoscin and must never be used unless fresh, as it decomposes in air and light. If given without morphin, it is inefficient. Large doses are certainly dangerous, and the combination should never be given in sufficient amount to induce anesthesia unaided. If used at all, it should only be as an aid to local anesthesia or to general anesthesia by ether or

chloroform. I have used it as an aid to local anesthesia in 6 goiter operations, and in 2 cases of removal of the Gasserian ganglion. It should not be used in heart disease (Hayem); in persons under sixteen or over sixty (Korff); in any one with a tendency to pulmonary edema or with any acute condition of the throat which interferes with respiration (A. C. Wood, in "American Medicine," Nov. 11, 1905).

It produces a drowsy, heavy state or actual sleep, and the patient can be kept unconscious with an extremely small quantity of ether or chloroform. For five or six hours after the operation the sleep continues, and in most cases there is not post-operative vomiting.

If it is used, a mixture is freshly made containing gr. $\frac{1}{100}$ of scopolamin and gr. $\frac{1}{6}$ of morphin, and this is given hypodermatically one-half an hour before the operation. During the operation the sleep may be maintained by ether or chloroform. If symptoms of poisoning occur, artificial respiration and oxygen inhalations may be required, external heat is needed, and nitroglycerin, strychnin, or caffein are given.

I agree with Kochmann that we are not as yet justified in recommending this method of anesthesia ("Münchener medizinische Wochenschrift," 1905, No. 17).

Local Anesthesia.—In every case requiring operation we should inquire whether local anesthesia can be used instead of general anesthesia. Many really extensive operations can be done under it and its field has been greatly broadened by the knowledge that viscera innervated by purely visceral nerves are insensitive and sensation exists only in those which receive branches from the somatic nerves (K. G. Lennander, in "Mittheilungen aus dem Grenzgebieten der Medicin und Chirurgie," Bd. x, Heft 1 and 2, 1902). Lennander shows that the parietal peritoneum is sensitive to pain, but not to touch—that the intestine, stomach, edge of liver, mesentery, gall-bladder, urinary bladder, kidney parenchyma, lung, anterior wall of the trachea, testicle, and epididymis are insensitive, though the coverings of the testicle and epididymis are sensitive. The advantages of operation under local anesthesia are freedom from the danger of anesthetic accidents, blood changes, and post-anesthetic discomforts and dangers. The disadvantage is the knowledge of the patient as to what is taking place. He may become alarmed and turbulent and may thus interfere with a necessary procedure at a vital moment. I have operated under local anesthesia with satisfaction in the following cases: Tracheotomy, rib resection, goiter, iliac colostomy, typhoid perforation, abscess of the lung, gangrenous appendicitis, radical cure of hernia, strangulated hernia, suprapubic cystotomy, extirpation of the external carotid artery (Dawbarn's operation), and ligation of the femoral artery. There are many methods of local anesthesia.

Freezing.—*Ice and salt* may be used. Take one-quarter of a pound of ice, wrap it in a towel, and break it into fine bits; add one-eighth of a pound of salt; then place the mixture in a gauze bag and lay it upon the part. The surface becomes pallid and numb, and in about fifteen minutes decidedly analgesic. A *spray of rhigolene* freezes a part in about ten seconds. It is highly inflammable. *Ether-spray* anesthesia was suggested by Benjamin Ward Richardson. *Chlorid of ethyl* comes in glass tubes (Fig. 628). Remove the cap from the tip of the tube and hold the bulb in the palm: the

warmth of the hand causes the fluid to spray out. Hold the tube some little distance from the part, and let the fine spray strike the surface. The skin blanches and whitens, and is ready for the operation in about thirty seconds.

Hypodermatic Injection of Cocain Hydrochlorate.—Always bear in mind that cocain is sometimes a decidedly dangerous agent. There are on record fourteen deaths from cocain (Reclus). The urethra is a particularly dangerous region, and so is the face. Never use more than two-thirds of a grain upon a mucous surface, and never inject hypodermatically more than one-third of a grain, and be sure never to inject the drug into a vein. Mild cases of cocain-poisoning are characterized by great tremor, restlessness, pallor, dry mouth, talkativeness, and weak pulse. In severe cases there is syncope or delirium. Death may arise from paralysis or from fixation of the respiratory muscles (Mosso). Cases with a tendency to respiratory failure require the hypodermatic injection of strychnin. In cases with tetanic rigidity of muscles give hypodermatic injections of nitroglycerin, or inhalations of the nitrite of amyl. In cases marked by delirium, if the circulation is good, give hyoscin. In any case give stimulants, employ a catheter, and favor diuresis. Cocain-poisoning is always followed by a wakeful night. Cocain should not be used if the kidneys are inefficient. In using cocain try to prevent poisoning. Because of the dangers inherent in cocain, have the patient recumbent. One minute before giving the cocain administer hypodermatically one drop of a 1 per cent. solution of nitroglycerin and repeat the dose once during the operation. In operating on a finger, after making the part anemic, tie a tube around the root of the digit before injecting cocain, and after the operation gradually loosen the tube. A hot solution of cocain is more efficient than a cold solution (T. Costa); hence hot solutions can be used in much less strength and are safer. The method of injection is as follows: A sharp needle is held at an angle of forty-five degrees to the surface, and is pushed into the Malpighian layer. One or two minims of a 2 per cent. solution are forced into the Malpighian layer, and a whitened elevation forms. The needle is withdrawn, at the margin of the wheal is reinserted, and more fluid is introduced, and so on until the region to be operated upon has been injected. After waiting five minutes the operation is begun. If, after cutting the skin, it is necessary to cut the subcutaneous tissue, pour a few drops of a 1 per cent. solution into the wound from time to time. After the completion of the operation, if a rubber band was used, it is loosened for a few seconds, tightened for a few minutes, again loosened and readjusted, and so on several times (Wyeth). In this way only a small quantity of cocain is admitted into the circulation at one time, and toxic symptoms are prevented. For operations upon the eye a 1 to 4 per cent. solution is employed; a drop of fluid is instilled every ten minutes until three drops have been given. Rarely use over a 10 per cent. solution on mucous membrane, although in laryngeal operations a 20 per cent. solution may be required. For the nasal mucous membrane a bit of wool soaked in a 5 per cent. solution is inserted or a spray of 4 per cent. solution is thrown from an atomizer into the nostrils. In the rectum, vulva, vagina, and uterus use a 5 per cent. solution; in the urethra, a 4 per cent. solution, and in the bladder, a 2 per cent. solution.

Cocainization of a Nerve-trunk.—Krogius has pointed out that if cocain is injected into the tissue about a nerve-trunk anesthesia will follow

in the area supplied by the nerve. The anesthesia will be produced in five minutes, and will last fifteen minutes. If cocain is injected about the root of the finger, all of the tissues of the digit will become insensitive. Injection over both supra-orbital notches renders the middle of the forehead insensitive. Injection over the ulnar nerve causes complete anesthesia of its trajectory. This plan is extensively used in Helsingfors.

It has been demonstrated by Crile ("Jour. Amer. Med. Assoc.," Feb. 22, 1902) that the injection of cocain into a nerve-trunk interposes an absolute block to the transmission of afferent and efferent impulses and greatly lessens operative shock. In 5 cases he employed this method to secure anesthesia for amputation of the leg, and 4 of the patients did not know that any operation was being performed.

Eucain hydrochlorate (β-eucain) is far safer than cocain, and in most cases is to be preferred to it. It is injected in the strength of from 2 to 5 per cent. It can be boiled without destroying its properties, and hence can be readily rendered sterile. It occasionally, though rarely, happens that the injection of eucain causes sloughing, especially at the extremities, in fatty tissue, in tendon-sheaths, and in bursæ. It can be used on mucous membranes.

Stovain.—This agent is a new local anesthetic introduced by Fourneau. It is as powerfully analgesic as cocain, is only one-third as toxic, and is slightly germicidal. It is dissolved in cold water, or salt solution and a solution used of the strength of 0.5 per cent. Adrenalin can be given with it (see Sonnenburg, in "Deutsche medicinische Wochenschrift," March, 1905).

Infiltration-anesthesia was devised by Schleich, of Leipsic, who was dissatisfied with cocain, because it is not safe and sometimes fails to produce complete local anesthesia, owing to want of thorough diffusion. He found that salt solution (0.2 per cent.), if injected into uninflamed parts, produced anesthesia. To obtain this anesthesia the part must be distended by wide infiltration. If minute quantities of cocain, morphin, and carbolic acid are added to the solution, the anesthesia becomes more thorough and more prolonged, and can be obtained even in inflamed areas.

Schleich uses three solutions:

No. 1, a strong solution, which is used in inflamed areas: cocain hydrochlorate, gr. iij; morphin hydrochlorate, gr. $\frac{2}{5}$; sodium chlorid, gr. iij; distilled sterile water, ℥iij$\frac{2}{5}$; phenol (5 per cent.), 2 drops.

No. 2, medium solution, which is employed in most cases: cocain hydrochlorate, gr. iss; morphin hydrochlorate, gr. $\frac{2}{5}$; sodium chlorid, gr. iij; distilled sterile water, ℥iij$\frac{2}{5}$; phenol (5 per cent.), 2 drops.

No. 3 is the weak solution used to infiltrate extensive areas: cocain hydrochlorate, gr. $\frac{1}{6}$; morphin hydrochlorate, gr. $\frac{2}{5}$; sodium chlorid, gr. iij; distilled sterile water, ℥iij$\frac{2}{5}$; phenol (5 per cent.), 2 drops.

The injections are begun *in* the skin, not *under* it (Fig. 629), and are made one after another until the area to be operated upon is surrounded above, below, and on all sides with Schleich's solution. At each infiltrated area a wheal forms in the skin. This infiltration can be made painlessly by touching with pure carbolic acid the point where the needle is to be inserted, or by freezing this spot with ethyl chlorid. After infiltration of the skin the surgeon waits ten or fifteen minutes and then operates, incision is made, and when deeper tissues are reached, they are infiltrated before incising them.

If a nerve comes in sight, touch it with a drop of pure carbolic acid. Van Hook says that the anesthesia obtained by this method is due to artificial ischemia, pressure upon the tissues, the direct action of the drugs, and the lowered temperature.* The method is very efficient, and can be used for operations of considerable magnitude. Matas uses a special apparatus to infiltrate the tissues. The fluid is driven by compressed air, and wide-spread or "*massive*" *infiltration* is produced. The addition of adrenalin chlorid to the cocain solution is an advantage, as it retards the circulation and hence favors analgesia and lessens bleeding during the operation. I do not believe that adrenalin in any way modifies the toxic action of cocain—in fact, Berry ("Am. Jour. Med. Sciences," Nov., 1905) seems to prove that it actually increases it. A satisfactory fluid for infiltration is 1 part of a 1 : 1000 solution of adrenalin chlorid and 9 parts of a 0.5 per cent. solution of cocain (Gangitans, in "Riforma Medica," Sept. 9, 1903). Eucain and adrenalin are preferred by some. Barker uses distilled water, 100 gm.; pure sodium chlorid, 0.8 gm.; β-eucain, 0.2 gm.; chlorid of adrenalin, 0.001 gm. After injecting this fluid the surgeon waits for twenty minutes before operating.

Anesthesia by Infiltration with Sterile Water.—When the tissues are well infiltrated with warm or cold sterile water, anesthesia ensues promptly. I have not found it as complete as when cocain or eucain is employed, even when a considerable amount of fluid is introduced. Gant uses it in rectal operations and commends it strongly ("New York and Phila. Med. Jour.," Jan. 28, 1904).

Cocainization of the Spinal Cord.—J. Leonard Corning in 1885 discovered that cocain injected between the spines of the eleventh and twelfth dorsal vertebræ produces analgesia of the lower limbs ("N. Y. Med. Jour.," Oct. 31, 1885). From this observation spinal anesthesia springs. Bier produced complete anesthesia of the entire body except the head by the injection of a small amount of cocain into the subarachnoid space of the spinal cord. A solution of cocain of a strength of from 0.5 per cent. to 1 per cent. is used by some, but cocain cannot be boiled without impairment of its anesthetic power, and carbolic acid must be added to it in small amount. Hence cocain so prepared is not certainly sterile, and the carbolic acid added may induce harmful symptoms. (See Neugebauer, in "Wien. klin. Woch.," 1901, Nos. 50, 51, 52.) Some surgeons use a solution of eucain which can be boiled, but it is not so rapid and certain as cocain. Some use tropacocain (Illwicz). A solution of this drug can be boiled, is less poisonous than cocain, and somewhat slower in action. Experimenters tell us that gr. ss to gr. iss may be given, but it is not wise to give over 0.5 of a grain.

The best plan is that of A. W. Morton. He takes chemically pure crystalline hydrochlorate of cocain, places it for fifteen minutes in a dry temperature of 300° F., and puts it in sterile tubes until wanted. The dose depends upon the locality in which we wish to induce analgesia, and varies between 0.3 gr. and 0.5 gr. The required dose is placed in the barrel of the sterile syringe and is dissolved in cerebrospinal fluid drawn into the syringe for that purpose. The syringe should be of glass, so that it can be boiled. The concave portion of the needle should be dull, so that a plug of skin will not be cut out and

* Med. News, Nov. 16, 1895.

obstruct the needle (A. W. Morton, in "Jour. Amer. Med. Assoc.," Nov. 8, 1902). The patient lies upon his side with the back curved. The back has been previously sterilized. The dressings are removed and the region to be punctured is resterilized. The spines of the third and fourth lumbar vertebræ are located, and the needle is entered in the mid-line beneath the spine of the third or fourth lumbar vertebra and is pointed upward and forward. The surgeon determines that he has punctured the subarachnoid space by lessened resistance and the appearance of fluid at the needle-opening. The syringe, with a closed piston, contains 0.3 gr. of sterile cocain. It is attached to the needle; the piston is withdrawn until the syringe is half full of cerebrospinal fluid. When the cocain is dissolved, the solution is slowly injected, the needle is withdrawn, and the puncture is sealed with collodion.

The anal region becomes anesthetic in from one to two minutes, the lower extremities in from three to six minutes, and the upper extremities in from fifteen to thirty minutes. The anesthetic condition lasts from one to three hours, or even longer, and is due to the contact of cocain with the nerve-roots (A. W. Morton, "Jour. Amer. Med. Assoc.," Nov. 8, 1902).

In performing the operation care must be taken to prevent the escape of cerebrospinal fluid.

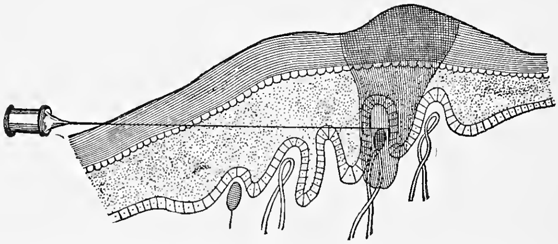


Fig. 629.—The syringe-point stops at the papillary layer, and the fluid lodges in the skin itself (Van Hook).

After cocainization of the spinal cord surgical operations can be performed on many regions without causing pain. Among the operations which have been performed are resection of the knee, resection of the ankle, osteotomy (Bier), amputation of the leg (Lower), and hysterectomy (Tuffier).

Cocainization of the spinal cord is not growing in popularity. It is regarded by most surgeons as rather a surgical curiosity. It should never be used as a routine procedure, and it will not displace ether or chloroform. By it analgesia can usually be secured. A. W. Morton ("Jour. Amer. Med. Assoc.," Nov. 8, 1902) has used it 673 times without a failure, and 60 of these operations were above the diaphragm. Most operators have had failures above the diaphragm. No one should attempt it who is not well trained in aseptic methods, because infection of the cord or its membranes will prove fatal. Whether or not ultimate harm ever comes to the cord is not certain. Bristow ("Brooklyn Med. Jour.," 1902, xvi, page 410) reports the case of a man, fifty-five years of age, on whom he operated for hemorrhoids after spinal cocainization. An examination one month later indicated degeneration of the posterior and lateral columns of the cord (spastic lower extremities,

ataxic gait, increased knee-jerks, ankle-clonus, and inability to retain urine). Marx ("New York Med. Record," Dec. 22, 1900) states that one case in his experience, after cocainization of the spinal cord, developed typical locomotor ataxia. Dandois ("Jour. de Chir. Brux.," April–May, 1901) reports a case upon which he had operated for traumatic rupture of the urethra. Spinal cocainization was employed. Paraplegia developed and lasted two months. Dr. Francis D. Patterson, who furnished me with the above references, writes me that there are several cases of hemorrhage into the subarachnoid space on record.

Is there any danger of death from cocainization of the cord? If the operation is not performed with scrupulous aseptic care, it is very dangerous. Even when performed by the best surgeons, death may occur. Dr. Francis D. Patterson, who has investigated this subject, writes me that Tuffier places the mortality at 3 in 2000, but excludes from consideration 3 deaths ("La Presse Médicale," vol. lv, 1901, page 190). Reclus finds 6 deaths in less than 2000 cases (Address before the Paris Academie de Médecine, March 19, 1901). Hahn, in 1708 cases collected from literature, found 8 deaths ("Mitt. a. d. Grenzgeb. d. Med. u. Chir.," 1900, iii, 337). Patterson's investigations persuade him that the mortality is about 3 in every 1000 cases. Wm. N. Perkins ("New Orleans Med. Jour.," Jan.–Sept., 1902) collected 2345 cases with 16 deaths or 1 death in 146 administrations.

Cocain seems to act like a toxin on the pia and arachnoid. Examination of fluid withdrawn after the performance of cocainization shows that it contains polymorphic leukocytes (Ravant and Aubourg, in "Gaz. Hebd. de Méd. et de Chir.," June 27, 1901).

Unpleasant after-effects are common. Among these are nausea, vomiting, sweating, overaction of the heart, involuntary evacuation of feces, cramps in the limbs, headache, chills, and shock. Many of these symptoms are probably due to absorption of cocain, but the headache must be due to tension, because it is relieved by the withdrawal of some cerebrospinal fluid by lumbar puncture (Ravant and Aubourg, in "Gaz. Hebd. de Méd. et de Chir.," June 27, 1901).

In a case in which, because of heart disease, pulmonary disease, kidney disease, or some other condition in which a general anesthetic is inadmissible, spinal cocainization is justifiable. I agree with Francis D. Patterson that spinal cocainization should be reserved for cases in which other forms of anesthesia are positively contraindicated.

Instead of cocain, eucain may be used to induce spinal anesthesia. It is safer although not quite so efficient. Sonnenburg and others have used stovain with success. A solution of Epsom salts has been used by Blake, Haubold, and Willy Meyer. It was discovered (Meltzer and Auer, "Am. Med.," Nov. 25, 1905) that subcutaneous injections of salts of magnesium produce local anesthesia. The same investigators later pointed out (S. J. Meltzer, "Med. Record," Dec. 16, 1905) that subarachnoid spinal injections produce wide-spread and complete anesthesia. A 25 per cent. solution is used and 1 c.c. of this is given for every 25 pounds of body weight. After a wait of three or four hours the drug causes paralysis and analgesia of the legs and pelvic region. Sensation and motion do not return for eight to fourteen hours. Retention of urine may last two days. The pulse and blood-pressure

are unaffected, but the respiration is slowed. Large doses would endanger life by respiratory arrest. In view of the fact that in some cases the effect of the drug is inordinately prolonged, it is wise, when the operation is completed, to puncture the theca of the cord again and wash it out with salt solution.

XXX. BURNS AND SCALDS.

Burns and scalds are injuries due to the action of caloric. Scalds are due to heated fluids or vapors. There is no true pathological difference between burns and scalds. Dupuytren classifies burns into six degrees, as follows: (1) Characterized by erythema; (2) characterized by dermatitis with the formation of vesicles; (3) characterized by partial destruction of the skin, which structure is not, however, entirely burned through; (4) characterized by destruction of the skin to the subcutaneous tissue; (5) characterized by destruction of all superficial structures and of part of the muscular layer; (6) characterized by "carbonization" of the whole thickness of the muscles.

The **symptoms** of a severe burn are local and constitutional. *Local symptoms* are pain and inflammation, which very in nature, in intensity, or in degree according to the extent of tissue-damage. *Constitutional symptoms* are very weak pulse, shallow respiration, and subnormal temperature —in other words, the condition of shock exists. The patient may die without reacting from shock, but in most cases there is reaction, followed by a severe reactionary fever, with a strong tendency to congestion of internal parts. During the existence of fever there may be vomiting, diarrhea, hemoglobinuria, albuminuria, and enlargement of the liver, spleen, lymph-glands, and tonsils. Marked blood changes follow burns (see "Clinical Hematology," by J. C. DaCosta, Jr.). There is a marked and rapid increase in red blood-cells (polycythemia). This is due in part to venous stasis and in part to loss of blood plasma. Leukocytosis is rapid and pronounced and there is a notable increase in blood plaques.

The blood has a marked disposition to clot, and clots may damage various structures or organs. Further, the altered blood damages the organs of excretion, and the liver and kidneys may cease properly to perform their functions. After a severe burn there are imperfect oxygenation and a tendency to universal fatty degeneration. The symptomatic stages are often designated as *prostration*, *reaction*, and *suppuration*. During the first forty-eight hours after a burn there are congestion in and about the burned area, severe pain, and possibly internal congestions. There may be shock and possibly toxic delirium or convulsions. From the end of the second to the end of the eighth or ninth day there are severe inflammation of the burned area, formation of sloughs, and a strong tendency to inflammation of the brain in head burns, of the lungs in chest burns, of the abdominal organs in abdominal burns, and of duodenal inflammation in any burns. Hyaline emboli in very unusual cases cause *Curling's ulcer* of the duodenum. Duodenitis and Curling's ulcer are possibly due, as Wm. Hunter suggested, to the bile having become irritant by the excretion in it of toxic matter ("A Manual of Surgical Treatment," by W. Watson Cheyne and F. F. Burghard). After the eighth or ninth day the sloughs separate from the burned area and healing begins.

The raw surface is slow to heal, hemorrhages may occur, the granulations are apt to be exuberant and edematous, and the scars are very contractile and often produce hideous or disabling deformity. If over one-half of the body-surface is badly burned, death will almost certainly occur, and probably within two days. The danger of a burn depends upon its extent, its depth, and its situation. Burning of a large area superficially is much more dangerous than burning a small area deeply. Burns of the extremities are not so dangerous as are burns of the head, chest, or abdomen. Death after severe burns is positively not due to loss of body-heat in the burned area. Some think it is produced by autointoxication with retained body-secretions. High temperature produces blood-changes—viz., disintegration of red corpuscles. Thrombosis may occur, and irritation of the kidneys and other organs is produced by "products of corpuscular degeneration."*

The blood of burned animals contains toxins (Kijanitzen), and so does the urine (Reis). It seems probable that the constitutional symptoms and death, if it occurs, are due partly to corpuscular disorganization, and partly to the absorption of toxic matter from the seat of injury, this matter having been formed by the action of heat on the body-cells and fluids. Sepsis is not infrequent. Death may be directly due to shock, to sepsis, to exhaustion, to embolism or thrombosis, to congestion of the brain, lungs, or kidneys, or to Curling's ulcer of the duodenum.

Treatment.—The *local treatment* of slight burns is to moisten the parts frequently with a saturated solution of bicarbonate of sodium, or a 1:8 solution of phénol sodique. In burns of moderate degree a mixture of zinc ointment with iodoform, though not antiseptic, is a comfortable dressing.

If a large surface is burned, remove the clothing with great care, and before applying dressings, give a hypodermatic injection of morphin, administer stimulants, and if the patient has a chill, place him in a warm bath. Use all ordinary means to secure reaction from shock. If we desire to dress a large burn aseptically, anesthetize the patient, spray the burnt area with peroxid of hydrogen, irrigate it with a solution of boric acid, dry with sterile cotton, dust with *Senn's powder* (three parts of boric acid and one part of salicylic acid), and dress with salicylated cotton. Senn's powder is better than iodoform. Iodoform may allay pain, but is apt to produce dermatitis. Change the dressing no oftener than is required, and at each change proceed as above described, although it will not be necessary to anesthetize. Peroxid of hydrogen softens and loosens the dressings, and they can be readily removed. The custom in the Jefferson Medical College Hospital is to give morphin and stimulants, to cut away the clothing, to wrap the unburned parts with blankets, and place about them cans or bags of hot water. The burned region is sprayed with peroxid of hydrogen contained in an atomizer, and irrigated with salt solution. Portions of epidermis which remain are retained. Any blisters are opened with a sterile needle, and the part is dressed with several layers of sterile lint or tarlatan soaked in normal salt solution, and the dressing is kept moist. During the second or inflammatory stage use stimulants and concentrated food, allay pain by opium or morphin, favor elimination by the skin, bowels, and kidneys, and combat any tendency

* Bardeen, in Johns Hopkins Hospital Bulletin, April, 1897.

to internal congestion or inflammation. In very extensive burns complete and continuous immersion of the part in warm salt solution is an excellent treatment.

The *picric acid treatment*, first suggested by Thiery, has many advocates. It greatly mitigates the pain. It is used early only in limited burns of the first and second degrees, but it can be employed in late stages of deep burns to stimulate the formation of epidermis. If used early in a large or a deep burn, it may poison the patient. It may poison a child when used upon a burn of the second degree. A case was reported by Dr. J. Stuart Rose ("Scottish Med. and Surg. Jour.," Dec., 1903), occurring in a boy of nine, who was treated with picric acid for a scald of the first degree, there being only one or two small blisters in addition to the redness. Ointment of picric acid was used (ʒss to an ounce of vaselin). Symptoms were noted three days after beginning the treatment. The symptoms are dark-colored urine (carboluria), albuminuria, marked yellowness of the skin, yellowness perhaps of hair at the scalp margins, diarrhea, and elevated temperature. Rose considers a 1 per cent. solution safe. It is applied as follows: The part should be disinfected, gauze saturated with a 1 per cent. watery solution of picric acid should be laid upon the burned area, and be covered with absorbent cotton and a bandage. This dressing is not changed for three to five days, and the next dressing can be left in place until the burn is healed. D'Arcy Power has carefully studied the real status of picric acid as a remedy for burns, and some of his conclusions have been set forth above.

Périer dresses a burn with a tarlatan compress, folded six times and soaked in the following solution: boric acid, ʒiiss; antipyrin, ʒiss; sterile water, ℥viij. The following ointment is used by Reclus: iodoform, gr. xv; antipyrin, gr. lxxv; boric acid, gr. lxxv; vaselin, ℥iss.

Carron oil consists of equal parts of linseed oil and lime-water. It allays the pain of a burn, but it is a filthy preparation, and its use is followed by much pus-formation. Cosmolin gives comfort as a dressing, but should not be used on the face, lest it cause pigmentation. The elder Gross used lead paint. A solution of nitrate of potassium allays the pain. In every burn of the fingers and toes keep the burnt digits separated by gauze, lint, or rubber tissue during healing, otherwise adjacent fingers will adhere and "*webbing*" will result. Where extensive destruction of tissue has taken place and healing has begun, use splints and extension to limit contractures, and skin-graft as soon as possible. If granulation is slow, stimulate with copper sulphate or mild silver-nitrate solutions. Exuberant granulations require burning down. Flabby granulations require pressure. If healing is slow, or if the burn is extensive, skin-graft. Skin-grafting should be done early in an extensive burn. If performed before much cicatricial tissue has formed, the graft will be more apt to adhere, and if the graft does grow fast, further formation of scar tissue will be greatly limited. When an extremity has been carbonized, amputation must be performed. The *constitutional treatment* of a severe burn is to bring about reaction; combat pain with opium; and keep the bowels and kidneys active. If suppuration occurs, give tonics, stimulants, and concentrated foods. Complications are treated according to general rules.

Burns and Scalds of the Tongue, Pharynx, Glottis, and Epiglottis.—A child or lunatic may drink boiling fluid or inhale steam from a

tea-kettle. Firemen occasionally suffer from scalds of the tongue and pharynx after being suddenly enveloped in a cloud of hot steam, and from burns by the inhalation of hot vapor or flame. Caustic may be taken into the mouth or swallowed. The tongue and pharyngeal mucous membrane swell greatly, large vesicles form, there are shock, severe pain, dysphagia, and dyspnea. Edema of the glottis may arise.

Treatment.—Combat shock; give morphin for pain; puncture vesicles, and have the patient almost constantly suck bits of ice. If great swelling occurs, make multiple longitudinal incisions through the mucous membrane of the dorsum of the tongue. If edema of the glottis begins, scarify it. If this fails, perform intubation or tracheotomy.

Burns of the Esophagus.—The esophagus is seldom scalded, as a boiling fluid rarely gets below the pharynx. The swallowing of an acid or alkali produces severe burns at the constricted portions of the gullet (page 802). Such an accident produces shock, dyspnea, violent pain, vomiting of blood, and thirst. Death may occur from shock or perforation of the stomach. In many cases severe gastritis follows a burn of the esophagus. As the acute symptoms of a burn of the gullet gradually abate, sloughs are cast off, ulcers form, cicatrization begins, and the signs of stricture develop (page 802).

Treatment.—Give a remedy to neutralize the caustic. Administer several large draughts of water and wash out the stomach. Combat shock. Give morphin for pain. Feed by the rectum as long as the patient's strength does not begin to fail. On beginning mouth-feeding, use at first milk and then beef-juice, jelly, and ice-cream. In from two to four weeks after the infliction of the burn begin the use of bougies to limit contraction.

Effects of Cold.—*Local Effects.*—Cold produces numbness, pricking, a feeling of weight, redness of the surface followed by stiffness, local insensibility, and mottling or pallor. Sudden intense cold causes the formation of blebs, the coagulation of blood in the superficial veins, and violent pain in the limb. Cold locally produces frost-bite (page 179).

The *constitutional effects* of cold are at first stimulating, then depressing, and are exhibited by uneasiness, pain, and an intense drowsiness which, if yielded to, is the road to death by way of internal congestion. Death from prolonged cold resembles in appearance death from apoplexy. Death from sudden and overwhelming cold is caused by anemia of the brain from weak circulation and capillary embolism. To bring a partly frozen person into a warm room may cause death by embolism.

Treatment.—Frost-bite is treated as outlined on page 180. When a person is nearly frozen to death place him in a *cool* room, but under no circumstance, in a cold bath; make artificial respiration, rub him briskly with flannel soaked in alcohol or in whisky, and follow this by rubbing with dry hands. After a time wrap the patient in warm blankets and give an enema of brandy. Mustard plasters are to be applied over the heart and spine. As soon as swallowing is possible brandy, is administered by the mouth. As the condition improves gradually raise the temperature of the room and give *hot* drinks.

Chilblain or **pernio** is a secondary effect of cold. It is really an area of local asphyxia (page 177). It usually appears as a local congestion upon the

toes, the ears, the fingers, or the nose, and now and then inflames and ulcerates. A chilblain is apt to become congested on approaching a fire or on taking exercise, and when congested, it itches, tingles, and stings. Frequent attacks of congestion produce crops of vesicles; these vesicles rupture and expose an ulcer, which in rare instances sloughs.

Treatment.—If chilblain affects the toes, prevent congestion of the legs and feet. Order large shoes and woollen stockings, and forbid tight garters. The patient with pernio must take regular outdoor exercise and must not loiter around a hot fire. Every morning and evening he should take a general cold sponge-bath, following by rubbing with alcohol and frictions with a coarse towel, and in winter he should sleep with warm stockings on or with his feet upon a warm-water bag. When a chilblain is only a congested spot, it should be washed twice a day in cold salt water, rubbed dry with flannel, and subjected to applications of tincture of iodin and soap liniment (1 : 2), tincture of cantharides and soap liniment (1 : 6), or equal parts of turpentine and olive oil (W. H. A. Jacobson). Jacobson says itching is relieved by painting belladonna liniment upon the part and allowing it to dry. Tincture of iodin may relieve it, and so may a mustard foot-bath. A valuable preparation for itching is composed of ʒj of powdered camphor and ℥iv of cosmolin. A little of this ointment is rubbed in twice a day. The following prescription, the source of which I do not remember, is very valuable for itching: ʒj of powdered camphor; ʒiss of ichthyol; ʒss of lanolin, and ℥iv of cosmolin, rubbed into the part and covered with cotton-wool. If vesicles form, paint with contractile collodion; if ulcers form, dress antiseptically. If ulcers are sluggish, use equal parts of resin cerate and spirits of turpentine. A good antiseptic and protective is the following: oxid of zinc, gr. vj; chlorid of zinc, gr. xx; gelatin, ʒij; distilled water, ℥j.

XXXI. DISEASES OF THE SKIN AND NAILS.

Dermatitis venenata results from irritants. It may be caused by wearing garments containing arsenic, but is generally due to rhus-poisoning. Rhus-poisoning arises from the poison-oak, the poison-ash, the poison-ivy, and other species of sumach. Actual touching of the plants is not always necessary.

The **symptoms** are burning and itching, redness and edema of the face and hands. A vesicular eruption begins between the fingers, and the eruption and the inflammation spread widely over the body. There may be slight fever.

The **treatment,** when a moderate area is involved, comprises the application of cloths wet with black wash or lead-water and laudanum. If an extensive area is involved, apply grindelia robusta (ʒiv to Oj of water) or moisten the surface frequently with sweet spirits of niter. Oxid of zinc ointment containing 10 gr. of carbolic acid to ℥j gives great relief. A 1 : 8 solution of phénol sodique allays pain and itching.

Furuncle, or **boil,** is an acute and circumscribed inflammation of the deep layer of the true skin and the subcutaneous cellular tissue following on bacterial infection of a hair-follicle or a sebaceous gland. A boil is caused by infection of a hair-follicle through a slight wound (by scratching, shaving, etc.)

with the staphylococcus pyogenes aureus. Boils are very common in individuals with Bright's disease, diabetes, gout, lithemia, tuberculosis, and disorders of menstruation and digestion; and crops of boils are apt to appear during convalescence from typhoid fever. Boils are commonest in the spring, and sometimes an epidemic of furunculosis appears in a hospital, a jail, or an asylum.

The **symptoms** of a boil are as follows: a red elevation appears, which stings and itches; this elevation enlarges and becomes dusky in color; a pustule forms, that ruptures and gives exit to a very little discharge which forms a crust. Inflammatory infiltration of adjacent connective tissue advances rapidly, and the boil in about three days consists of a large, red, tender, and painful base capped by a pustule and a little crusted discharge. In rare instances, at this stage, absorption occurs, but in most cases the swelling increases, the discoloration becomes darker, the skin becomes edematous, the pain becomes severe and pulsatile, and the center of the boil becomes raised. About the seventh day rupture occurs, pus flows out, and a "*core*" of necrosed tissue is found in the center of a ragged opening. This core consists of the sebaceous gland and hair-follicle, which have undergone coagulation necrosis (Warren). In a day or two more the core will be discharged, and healing by granulation will begin. A *blind boil* lasts only three or four days and has no core. The constitution often shows reaction during the progress of a boil. Boils may be either single or multiple. The development of one boil after another, or the formation of several boils at once, is known as "*furunculosis*." Boils are commonest upon the neck and the back.

The **treatment** consists of crucial incision, removal of necrotic tissue, irrigation with peroxid of hydrogen, touching with pure carbolic acid, and the application of hot antiseptic fomentations.

Aleppo boils (*endemic boils of the tropics*) are papules appearing upon the exposed parts of the body. These papules, which ulcerate and do not cicatrize for at least a year, are due to a pathogenic bacterium and leave ineradicable scars.

Carbuncle (*benign anthrax*) is a circumscribed infectious inflammation of the deeper layer of the true skin and of the subcutaneous tissue, with fibrinous exudation, multiple foci of necrosis arising, and the tissue adjacent to each necrotic plug becoming gangrenous. The infection takes place through a hair-follicle. It is really a boil with extensive infiltration of adjacent tissues. A boil may become a carbuncle, and pus from a carbuncle inoculated into a healthy person may cause either a boil or a carbuncle. The causative organism seems to be the staphylococcus pyogenes aureus. Carbuncle is most common in the upper part of the back and on the back of the neck. In this region the skin is very thick; each hair-follicle holds only a downy hair, is shallow, and projects but a short distance into the cutis vera. Columns of fatty tissue run from the subcutaneous tissue in an oblique direction to join the point and sides of the hair-follicle. These columns are known as *columnæ adiposæ*, and each one contains a sweat-gland (Fig. 630). When pus runs down one of these columns, it seeks an outlet; it cannot spread easily to the sides, so it slowly works its way to deeper tissue and from one to another interspace and finds its way to the surface through other fatty columns (Warren's "Surgical Pathology") (Fig. 631). When

pus finds its way to the surface, an opening forms, hence the numerous foci of pointing; finally a large opening forms (Fig. 632). Carbuncles are most common in the spring of the year. In persons with diabetes and Bright's disease carbuncles not unusually occur.

The local **symptoms** in the beginning resemble those of a boil, but the constitution sympathizes from the very start (perhaps a chill and always a septic fever) and the pain is usually severe. The inflammatory area begins as a papule with an indurated base, it enlarges enormously, is boggy to the touch, is dusky in color, is edematous, and the skin is not freely movable over the deeper parts. In a few days many pustules appear, each pustule marking the site of a focus of necrosis. Large vesicles filled with bloody serum very frequently form. In some cases, about the tenth day, the pustules rupture, the necrotic plugs are discharged, and the case slowly progresses toward cure; but in many cases the carbuncle spreads at the periphery while pustules are rupturing near the center of inflammation, and pus forms in the deeper tissues, reaching the surface through many small openings, each of which is partly blocked by a plug of dead tissue. A carbuncle in this stage resembles a honeycomb (Fig. 632), discharges bloody pus, and large masses of skin and subcutaneous tissue are destroyed. The entire carbuncular mass may become gangrenous, and a sudden and almost complete cessation of pain points to this complication. An ordinary carbuncle remains acute for about three weeks, but healing requires a month or more. The most dangerous situations in which to have a carbuncle are the face and neck (tends to produce septic phlebitis, septic clots in the facial, jugular, or ophthalmic veins, or in the cerebral sinuses, or infective emboli). The mortality of facial carbuncle is at least 50 per cent. The most usual positions for carbuncle are the neck, the back, and the buttocks. The diagnosis of carbuncle is made by noting the multiple foci of necrosis and the profound constitutional involvement. A carbuncle may produce death by causing septicemia, pyemia, or profuse hemorrhage.

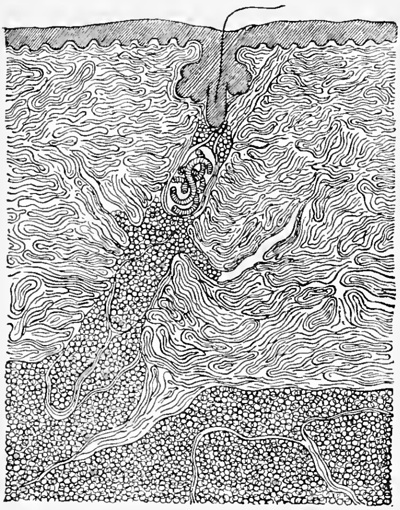


Fig. 630.—Columna adiposa (Warren).

Treatment.—Some have suggested the treatment of a carbuncle in an early stage by injecting from five to thirty drops of carbolic acid (80 per cent.) into and around the inflammatory mass. Such a method does not promise success and necessitates dangerous delay. The best treatment if the case is seen sufficiently early is thorough extirpation while the patient is anesthetized. The entire area of the infection is thus removed, and the large wound heals by granulation and is subsequently skin-grafted. When the condition is too far advanced to admit of complete extirpation, the following useful plan should be employed:

Give ether, make free crucial incisions, remove dead and necrosing tissue and also the points of the skin-flaps with the scissors and forceps, curet pockets, arrest hemorrhage by pressure and hot water, cauterize with *pure* carbolic acid, dust with iodoform, pack with iodoform gauze, and dress with hot antiseptic fomentations. Cover the gauze with a piece of some impermeable material and lay a hot-water bag upon the dressing. Every day, or several times a day, remove the dressings, wash with peroxid of hydrogen, irrigate with corrosive

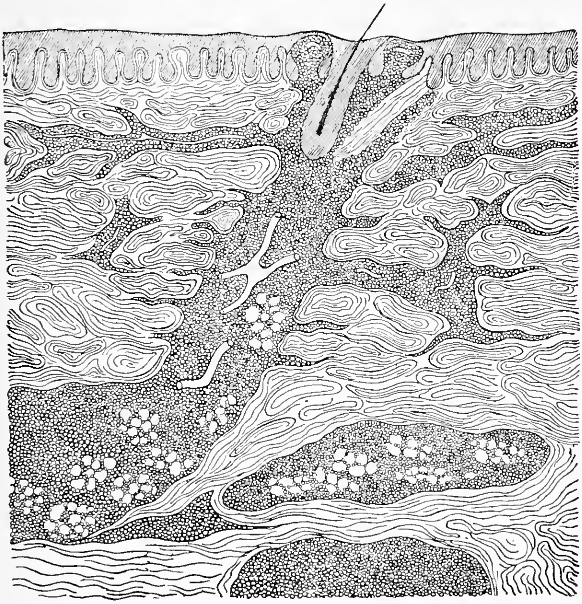


Fig. 631.—Infiltration of columna adiposa and subcutaneous tissue with pus in carbuncle (Warren).

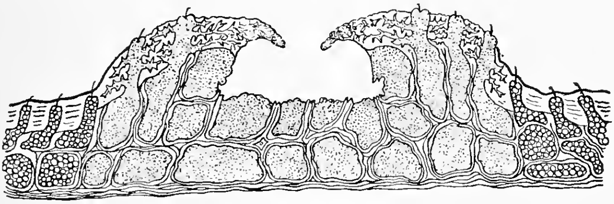


Fig. 632.—Diagram of a carbuncle (Warren).

sublimate solution, dust with iodoform, and reapply the iodoform gauze and antiseptic fomentation. Keep up this treatment until sloughs are separated, then dress with dry antiseptic gauze. Secure sleep by morphin, give quinin, milk-punch, and nourishing diet, and maintain the action of the bowels and kidneys.

Erysipelas.—(See page 200.)

Clavus or Corn.—A corn is a tender, painful, and circumscribed

thickening of the epidermis, and is commonest over one of the joints of the toes. *Hard* corns are situated on exposed parts of the digits; *soft* corns appear between the digits, where the parts are kept constantly moist. Corns are caused by pressure.

Treatment.—The wearing of well-fitting boots will usually cause a corn upon the toe to disappear. Soak the feet often in water containing bicarbonate of sodium, dry them, and apply a circular corn-plaster to the corn to take off the pressure of the boot. Another method is to touch the corn with iodin every night and pare away the hard tissue every morning. An old and valuable plan is to paint the corn every night and morning for several days with a mixture composed of salicylic acid, gr. xl; extract of cannabis indica, gr. x; and collodion and flexible collodion, of each, ʒij; then soak the parts in hot water and scrape away the mass. *Soft* corns are treated by washing the feet often with ethereal soap, drying, gently removing the sodden epithelium, dusting the toes and between them with borated talc, and placing absorbent cotton between the digits. Incurable soft corns require the removal of the skin from the adjacent sides of the two toes and suturing them together (thus converting two toes into one). In inflamed corns employ rest and lead-water and laudanum, and let out pus when it forms. Remember that in old persons the cutting of a corn may cause senile gangrene. In the inflamed and painful feet of a person who has corns nothing gives so much relief as washing the feet with ethereal soap, soaking in hot water, and wrapping the feet for half an hour in cloths wet with a mixture composed of linseed oil and lime-water, each, ℥ij, and spirits of camphor, ʒj.

Warts.—(See page 327.)

Onychia is inflammation of the matrix of the nail. Syphilis often causes severe onychia which requires specific treatment (page 283). A "*run-around*" or paronychia is suppuration of the matrix at the root of the nail, and of the skin about it, of traumatic origin. It requires incision, trimming away of the buried edge of the nail, and packing with iodoform gauze. Syphilitic paronychia is referred to in page 283.

Malignant onychia, which is inflammation and ulceration of the entire matrix, occurs only in a person of dilapidated constitution. This condition requires removal of the entire nail, cauterization of the matrix, dressing with iodoform gauze, and the internal use of stimulants, tonics, and nourishing diet.

Ingrowing toe-nail (page 163) is sometimes due to lateral hypertrophy of the edge of the nail, but usually to forcing of the soft tissue over the margin of the nail. An irritable ulcer arises. The condition is treated by splitting the nail, removing the ingrown piece, the soft tissue at the margin, and the adjacent matrix, and dressing antiseptically.

XXXII. DISEASES AND INJURIES OF THE THYROID GLAND.

The thyroid gland possesses important nutritive functions. Kocher pointed out that its complete removal in a young or middle-aged person usually causes *operative myxedema* (*cachexia strumipriva*) and perhaps *tetany*. Removal of the gland in an elderly person does not cause these curious conditions. Later knowledge indicates that removal of the thyroid with the parathyroids certainly produces myxedema or tetany, unless aberrant thyroids exist and compensate. Removal of the thyroid without the parathyroids may not induce permanent grave consequence, even when there are no aberrant thyroids. The thyroid furnishes an internal secretion which destroys certain toxic products of metabolism. It is thought that the parathyroids furnish an antitoxin to poisons formed during digestion.

Wounds cause violent hemorrhage which is difficult to arrest. Ligatures may cut out and forceps will not hold. The hemorrhage is arrested by suture ligatures, purse-string sutures, the actual cautery, or removal of the bulk of the gland.

The thyroid gland may be **absent** at birth. **Congenital atrophy** or **congenital hypertrophy** may exist.

Acquired atrophy leads to *myxedema*, a condition characterized by the presence of a firm subcutaneous swelling in the face, neck, and limbs; slow speech; mental dulness; and subnormal temperature. The condition is identical with that produced by removal of the entire gland.

Cretinism is a form of idiocy due to atrophy of glandular elements in the thyroid, although the size of the gland is often increased. The body is dwarfed; the face, neck, and extremities resemble those parts in myxedema, and a low grade of idiocy exists. Myxedema and cretinism are treated by the internal administration of thyroid extract.

Congestion of the thyroid may be caused by violent exertion, prolonged effort, febrile maladies, and venous obstruction. It is treated by removing the cause and applying heat locally. Tracheotomy may be required.

Inflammation of the thyroid (*acute* or *inflammatory goiter*) may be induced by a septic or febrile malady, rheumatism, muscular strain causing vascular rupture, a wound or contusion of the thyroid. But one lobe is affected. The ordinary symptoms of inflammation are present. In addition there are dysphagia, dyspnea, venous congestion of the face, epistaxis, nausea and vomiting, and possibly delirium. It may terminate in resolution, suppuration, or fibrous induration.

Tuberculosis of the Thyroid.—Is usually a part of general miliary tuberculosis. It is very seldom that a local caseating focus occurs, but such cases have been reported.

Syphilis of the Thyroid.—Early in the secondary stage there is apt to be slight and painless thyroid enlargement. In the tertiary stage gummata may form.

Tumors of the thyroid are of various sorts. Among them are adenomata, cystic adenomata, sarcomata, and carcinomata. Eight cases of teratoma are on record (Isabella C. Herb, "Am. Jour. Med. Sciences," June, 1906). Malignant disease is unusual. I have operated on but two cases: one of cystic car-

cinoma in which operation was rapidly fatal, and one of round-celled sarcoma, which is living and apparently well one year after partial thyroidectomy. Malignant disease may arise in the normal but is more apt to arise in a goitrous thyroid. Sarcoma or carcinoma may occur, and it is seldom possible to determine clinically with which we are dealing. Sarcoma (Fig. 633) may involve one lobe, but carcinoma (Fig. 634), even at an early stage, is apt to involve both lobes (Berry on "Diseases of the Thyroid Gland"). These growths soon penetrate the gland capsule, become anchored to surrounding parts, and involve the vocal cords, trachea, and even the great vessels of the neck. It is after the fortieth year that malignant growths may be met with: they are hard and nodular and grow rapidly. At first the gland moves with deglutition, but later becomes anchored to surrounding parts. In malignant disease of the thyroid it is usual to find difficulty of swallowing and paralysis of the vocal cord on the side of the growth. Malignant disease is rapidly fatal. Many die within six months and few survive over eighteen months. Radical operation is proper only before the growth breaks through the capsule, although at any stage it may be necessary to operate in order to prevent suffocation.

Fig. 633.—Sarcoma of thyroid gland.

Goiter. — A goiter is an enlargement of the thyroid gland not due to a malignant tumor or to inflammation. The enlargement may affect a small portion of the gland, one lobe, both lobes, or both lobes and the isthmus, and it may occur either sporadically or endemically.

Fig. 634.—Cystic carcinoma of thyroid gland.

There are a number of forms of ordinary goiter. The most common is what is called *parenchymatous goiter* (Fig. 636). In this condition all portions of the gland enlarge, and the goiter is consequently bilateral. It does not appear first in one lobe and at a considerably later period in the other, but each lobe is enlarged equally or nearly equally. Parenchymatous goiter is often spoken of as simple goiter, and is sometimes, though not with entire accuracy, designated hypertrophy of the thyroid gland.

Fig. 635.—Adenomatous goiter.

Adenomatous goiter (Fig. 635) is a condition due to the growth of encapsuled adenomata in the thyroid gland. It may be a single adenoma, but frequently there are multiple growths. One or both lobes may be involved. The goiter, however, seems to begin in one lobe; and if both lobes enlarge, one does so at a period distinctly subsequent to the enlarging of the other. Adenoma may develop in a healthy thyroid gland, but adenomatous growth is usually associated with some parenchymatous growth.

Cystic goiter, or *bronchocele*, is a condition in which the chief mass of the enlargement is composed of a cyst or of multiple cysts. When cysts form, the thyroid gland is usually hypertrophied or adenomatous; occasionally, however, cysts form in a non-hypertrophied thyroid. The great majority of cysts are due to cystic degeneration of adenomata; some are formed by the running together of overdistended thyroid vesicles, and some few follow blood-extravasation into the thyroid tissue. The liquefaction is due to mucoid or colloid degeneration, and the fluid of the cyst is sometimes clear and thin, sometimes viscid, and often coffee-ground in appearance.

Fig. 636.—Parenchymatous goiter.

A *fibrous goiter* is a fibrous induration. It is likely to arise in old bronchoceles, which may actually pass into a calcareous condition. By the term *malignant goiter* is meant malignant disease of the thyroid gland, either carcinoma or sarcoma. As stated above, such cases are not really goiters.

When hemorrhage takes place into a goiter, the condition is often spoken of as a *hemorrhagic goiter.* A *colloid goiter* is a form of parenchymatous goiter in which there is an extremely large amount of colloid material. *Exophthalmic goiter* is discussed on page 1067. Occasionally an ordinary goiter becomes exophthalmic. This evolution gives rise to what the French call a *Basedowified goiter* (see Morestin, in "Rev. de Chir.," Nov. 10, 1899). A goiter that develops with great rapidity is sometimes called an *acute goiter*, and one that induces marked dyspnea is designated a *suffocating goiter.* Syphilitic, tuberculous, and amyloid enlargements are extremely rare, but occasionally occur. Further, a goiter may be back of the sternum, that is, *substernal* or *retrosternal.* A goiter within the thorax is called *intrathoracic;* and such a goiter may be *retrosternal*, *retrotracheal*, or *retro-esophageal.* When a number of persons in the same region are attacked with goiter, the condition is frequently referred to as *epidemic goiter.* When the condition is common in a certain district, it is called *endemic goiter.* When a person living in a district in which the disease is rare develops goiter, we speak of the condition as *sporadic goiter.* It has long been known that *accessory* or *aberrant thyroids* exist. The term aberrant is better than accessory because in some reported cases the thyroid proper was absent (V. L. Schrager in Surgery, Gynecology, and Obstetrics, Oct., 1906). Aberrant thyroids are masses of tissue composed of structure identical with the thyroid gland, and distinct and separate from the thyroid gland proper. Median accessory thyroids are found about the hyoid bone and are formed from remnants of the thyroglossal duct. Lateral accessory thyroids are found and develop from the remains of the lateral anlages of the thyroid (Schrager). Aberrant thyroids vary in number: there may be none, one, several, or chains of them. An aberrant thyroid may enlarge with the thyroid, may not enlarge even though the thyroid does, or may enlarge when the thyroid proper remains normal. When cachexia strumipriva does not develop after complete thyroidectomy including the parathyroids, the patient has been saved by enlargement and functionation of accessory thyroids.

Causes of Goiter.—It is known that goiter is extremely common in the valleys at the foot of certain mountain ranges in Switzerland, southeastern France, northern Italy, the Austrian Tyrol, and in the Himalayas and the Andes. In a portion of England it is so common that it is referred to as the Derbyshire neck. It seems evident that the disease is due to the introduction of some poisonous element into the system; but what this element is, is not positively known. Some writers maintain that individual liability is developed by habits of life; others think that susceptibility depends upon hygienic surroundings; and some attach great importance to hereditary influence. The probability is, however, that the disease is due to the existence of some poisonous substance in the drinking-water. Some observers have blamed snow-water; many have laid the cause of the trouble at the door of water impregnated with salts of lime; but the real cause has not been positively demonstrated.

An ordinary parenchymatous goiter seems to be a species of hypertrophy. A number of years ago I suggested the view that the gland has undergone such an enlargement and has become distended with colloid material because the human body has demanded more of the secretion of the gland than the normal gland has been able to supply; as a consequence, the normal gland has enlarged its capacity and increased its output.

Symptoms of Goiter.—One may determine that a growth is in the thyroid gland or is connected with it by studying a number of facts. A goiter, as a rule, follows the movements of the larynx and the trachea during deglutition, and this sign may be obtained in the great majority of instances. There are, however, rare conditions, such as hyoid cyst, in which a movement of the mass takes place during the act of swallowing, although the thyroid gland is not involved. Then, again, a malignant or an inflammatory growth of the thyroid usually becomes anchored to the surrounding tissues and does not show this mobility. Certainly, however, in the greater number of the cases the goiter moves with the larynx and the trachea during swallowing.

Goiters vary greatly in size. Cases in which the goiter was as large as an adult's head, and some cases in which the goiter hung in front of the breast-bone and reached to below the level of the ensiform cartilage, have been described. A very large goiter may have a stalk.

When the entire gland, as well as the isthmus, is enlarged, or when the isthmus alone is involved, the swelling may appear to be in the median line of the neck. If the condition begins in one lobe, the growth will, for a time at least, be distinctly one-sided; though when such a growth has attained a large size, it may displace the windpipe and come itself to the middle line of the neck.

A goiter of any considerable size pushes the sternocleidomastoid muscle externally and anteriorly, and the muscles that run from the sternum to the hyoid bone and to the thyroid cartilage overlie the front of the growth. The carotid artery is displaced externally and posteriorly. The relation of the jugular vein to the carotid artery is usually profoundly altered. The artery, as already stated, goes externally and posteriorly, while the vein is actually pulled anteriorly and is flattened out upon the side or the anterior surface of the goiter; hence the vein comes to lie to the inner side of the artery. This curious alteration in relationship is due to the fact that the common carotid artery has no branches, and therefore is pushed externally with ease; but the internal jugular vein receives branches that lie in the tumor, pull upon the vein, and prevent its displacement with the artery (Lücke).

Berry alludes to the fact that the tumor, unless it is very small, usually reaches the upper level of the sternum, and frequently passes below this level; and that only extremely large goiters hang in front of the sternum, but that it is not at all unusual for prolongations from a goiter to extend for quite a distance into the mediastinum. A substernal goiter is productive of very dangerous symptoms and offers many difficulties in diagnosis. A goiter will occasionally wander, now appearing in the neck and again disappearing behind the sternum.

Some goiters are said to pulsate. This takes place in exophthalmic goiter, the vessels of the goiter pulsating as do the other vessels of the body; but in the ordinary simple goiter, what is called pulsation of the goiter is usually the transmitted pulsation from the carotid artery.

Some of the most important symptoms of goiter are due to pressure and to the displacing of anatomical structures. Pressure upon the veins at the root of the neck causes great enlargement of the veins above the goiter and in it. Pressure upon the recurrent laryngeal nerve may induce characteristic symptoms (spasm of the glottis or paralysis of a vocal cord), but the dyspnea

of goiter is due to pressure upon the trachea and not to interference with the recurrent laryngeal. Paralysis of a vocal cord is rare in non-malignant, common in malignant, goiter. Pressure upon the cervical sympathetic may cause contraction of the pupil and narrowing of the palpebral fissure (Berry). Pressure upon the cervical plexus or the brachial plexus causes paresthesia, anesthesia, or paralysis in the parts supplied by nerves from the compressed plexus. Pressure upon the larynx and the trachea may cause very great displacement, and any such displacement is productive of marked dyspnea. This displacement is usually to the side; and it may cause such a flattening out of the tracheal rings that when the tumor is removed, the trachea collapses and the patient perishes of suffocation.

A parenchymatous goiter usually begins insidiously and grows slowly. It occasionally ceases to grow for a considerable period of time, and may even shrink. It frequently enlarges temporarily during menstruation or pregnancy, and occasionally attains an enormous size by changing into the cystic form. Alterations in its consistency and outline may be due to the developing of adenomatous masses.

In making a diagnosis between the different forms of goiter, one should remember that a fairly symmetrical, bilateral growth is probably parenchymatous; that sudden enlargements are produced by hemorrhage; that cyst-formation may lead to very great enlargement, and possibly to fluctuation; that if a non-malignant goiter induces dyspnea, it almost invariably does so by pressing upon the larynx and the trachea, whereas a malignant goiter may do so by interfering with the nerves of the part; that a non-malignant goiter very rarely produces difficulty in swallowing, but that a malignant goiter frequently does so; and that cough often exists if there is pressure upon the larynx or the trachea, such a cough being metallic in nature and unassociated with impairment of the voice.

In any goiter there may be cerebral symptoms, such as anemia, syncope, or even convulsions. Rapidly growing goiters are often fatal, and slowly growing goiters are very rarely so. A malignant goiter grows with great rapidity, becomes adherent, infiltrates, and quickly produces metastases, and both sarcoma and carcinoma produce metastases by way of the venous system.

Metastasis of Non-malignant Goiter.—An ordinary goiter which presents no sign of being malignant may suddenly be disseminated. The deposits are apt to take place in the bones and in the lungs. Tumors have been removed without any thought of thyroid trouble being responsible, and examination has shown thyroid structure. Patel collected 18 cases of thyroid metastasis ("Tumeurs bénignes du corps thyroide donnant des métastases," "Revue de Chirurgie," 29, 1904). The bones most apt to receive metastases are the bones of the cranium, the lower jaw, the vertebræ, the pelvis, and the long bones. In 4 of these 18 cases the spine was affected. Dercum has reported a case of thyroid metastasis to the spine ("Journal of Nervous and Mental Diseases," March, 1906). Colloid goiters are particularly prone to metastasis. Some surgeons maintain that if a metastatic deposit grows and destroys bone, the primary tumor should be regarded as malignant no matter what histological studies indicate.

Treatment of Goiter.—Iodid of potassium and arsenic internally have been advised; ointment of red oxid of mercury locally is advocated by some

writers. The administration of thyroid extract may do much good in a case of parenchymatous goiter, but it is useless in other forms of the disease. It should be associated with the local use of tincture of iodin or ointment of red iodid of mercury. In times past it was customary to treat cystic goiters by aspiration and injection with a solution of iodin. Electrolysis may benefit a soft goiter, the negative pole being pushed into the growth, the positive pole being applied to its surface. In some cases the *x*-rays may prove of benefit. In considering the propriety of operation remember that a goiter which begins at puberty may pass away. We should operate on every non-malignant goiter which is increasing rapidly in size, and on every goiter which causes much respiratory trouble, but should not operate simply for deformity (Bergeat). If enucleation or extirpation is performed, do not give ether or chloroform. These agents greatly increase bleeding and are dangerous. Do the operation with the aid of local anesthesia (cocain, eucain, or Schleich's fluid). It is a great advantage to have the patient conscious, because by asking him to speak during the operation the surgeon can tell if the recurrent laryngeal nerve is being touched. In many cases intraglandular *enucleation* is performed, in other cases *extirpation*. Occasionally these two methods are combined (Bergeat). Some surgeons advise simple division of the isthmus. Ligation of the thyroid arteries has been recommended. *Exothyropexy* is the operation of exposing the thyroid gland, dislocating it through the wound, and leaving it in this situation. Atrophy of the gland follows the operation. Enucleation, if possible, is the desirable operation. It may easily be employed for the removal of a single adenomatous, colloidal, or cystic area. *Thyroidectomy* or extirpation is employed when enucleation is impossible. The entire thyroid is not removed for an innocent growth: a portion of the gland is left behind, otherwise operative myxedema will probably arise. Unilateral extirpation is the method usually chosen. In sarcoma or cancer of the thyroid complete extirpation may be attempted. The operation in malignant disease will occasionally prolong life, but it will rarely effect a cure. In malignant disease tracheotomy may be rendered necessary by urgent dyspnea. The operation is often very difficult because the growth may cover the trachea, the trachea may be deviated a considerable distance from its proper position, and the veins are very large. After the performance of the operation it is usually impossible to use an ordinary tracheotomy tube, and in such a case Koenig's long, flexible tube is employed (Fig. 637).

Fig. 637.—Koenig's tracheotomy tube.

Exophthalmic Goiter (*Graves's Disease, Basedow's Disease; Pulsating Goiter*).—This condition was first described by Graves, of Dublin, in 1835. It is vastly more common in women than in men, and is most common between the ages of twenty and forty. It may arise at puberty. It has been stated that child-bearing has little influence in its causation, but I have seen the development of it in a woman three times in three different pregnancies. There is not proof of heredity, but it is not unusual to find more than one member of a

family with it. It is not particularly prone to appear in ordinary goitrous families, although a person with an ordinary goiter sometimes develops it. It may arise after emotional excitement or depression, fright, shock, hemorrhage, or an acute illness. It may develop during the existence of locomotor ataxia, paresis, epilepsy, neurasthenia, hysteria, and other nervous troubles, and abdominal and pelvic diseases. Digestive toxemia may be responsible in some cases. It is frequently associated with marked anemia, the result of excessive vomiting. Many believe that the disease is a toxemia and that the real cause is hypertrophy of the thyroid and excessive secretion of the gland. This view is rendered more probable when we recall that a condition known as myxedema possesses many symptoms directly opposite to those of Graves's disease and that myxedema is due to absence of thyroid secretion (Richardson, on "The Thyroid"). The administration of thyroid extract to an individual may produce some symptoms observed in exophthalmic goiter and partial thyroidectomy may improve or cure the disease. Thyreoglobulin is probably the poisonous element.

Fig. 638.—Exophthalmic goiter and total blindness from protrusion of eyes (Hansell).

An objection to this view is that Graves's disease may exist without detectable thyroid enlargement, but this view loses force when we recall that the thyroid may be somewhat enlarged though we cannot detect the increase. It is probable in exophthalmic goiter that whether or not there is an excess of thyroid passing into the circulation toxic products of some sort are formed in the gland and are taken into the lymph and blood. The real cause of exophthalmic goiter is not positively proved, but it seems probable that the disease is due to the action on the sympathetic system of large amounts of thyroid material or of some poisonous product of thyroid activity.

In exophthalmic goiter the vessels of the gland are not dilated—in fact, they are "usually smaller and less numerous than in a parenchymatous goiter of the corresponding size" (Berry on "Diseases of the Thyroid Gland"). The surface of the gland is smooth. On section, the cut surfaces seem solid and very little colloid is visible. The enlargement is due to growth of the glandular epithelium, and this epithelial proliferation may be induced by the different exciting causes previously mentioned.

In exophthalmic goiter the lymphatics within the lobules are usually ob-

literated, and the lymphatics around the lobules are present in increased number and are of exaggerated size. Sometimes the thyroid becomes fibrous, and in such cases myxedema is apt to arise. In a typical case there are rapid pulse or *tachycardia;* protrusion of the eyeballs or *exophthalmus* (due to a collection of fat back of each eye), and enlargement of the thyroid gland or goiter. Either thyroid enlargement or exophthalmus may be absent—in fact, in some rare cases both are absent. The enlargement of the thyroid is bilateral. Supposed unilateral enlargements are instances of Basedowified goiter—that is, are cases in which an ordinary goiter gives rise to the symptoms characteristic of Graves's disease. A systolic bruit is usually audible over the thyroid region, and the large vessels at the root of the neck pulsate strongly because of arterial dilatation. The cardiac symptoms are of great importance. Cardiac dilatation occurs during tachycardia, and for a time, at least, disappears as tachycardia abates. Even trivial fatigue brings on temporary dilatation. Dilatation may become permanent, valvular insufficiency may arise, or cardiac hypertrophy may occur (see Grocco, in "Riv. Crit. di Clin. Med.," Jan. 2, 1904). *Von Graefe's sign* may be present; this consists of retraction of the eyelids and inability of the lids to follow the eyes in looking down. The lids in some cases cannot be completely closed, and when the eyeball is suddenly turned up, the lid and brow may fail to act together. In some cases ocular palsies exist, in others there is photophobia or nystagmus. Patients may suffer from neuralgia, colic, choreic movements, tremor, flushes of heat, and gastric crises. Dyspnea often exists, and albuminuria and polyuria are not uncommon. Hemoptysis, hematemesis, or mental disturbance is sometimes noted. The patient is usually greatly depressed mentally, sometimes is excited, and may have outbreaks of violent hysterical excitement or even of mania. The usual expression is one of fright. There may be insomnia, polyuria, elevated temperature, excessive sweating, or albuminuria. The duration of a case is entirely uncertain. It is usually very chronic, with remissions or actual intermissions. Sometimes the patient gets entirely well, but this result is rare. There is often a partial cure which may at any time be followed by a renewed outbreak. Sometimes the condition passes away rapidly, but abatement is usually gradual. Some cases get progressively worse and die. Certain cases are acute and these are apt to result fatally. A man in the Jefferson Hospital died in five weeks after the first symptoms were noted. He was delirious for several weeks.

Treatment.—Thyroid extract does harm. Medical treatment in a severe case should comprise rest in bed, the use of an ice-bag over the heart, and the administration of adrenalin. When the patient gets about again, he must avoid alcohol and all forms of excitement. Gentle exercise is desirable, but never violent exercise. Diet is to be nutritious, but non-stimulating. Electricity is said to be of benefit. Thymus extract has been used. Experiments in organotherapy are being tried in this disease. Ballet and Enriquez assumed that the thyroid gland furnishes an antitoxin to certain body poisons, that an excess of thyroid secretion over the amount required to neutralize toxin causes the condition known as Graves's disease, and that the symptoms of Graves's disease should disappear if sufficient toxin is administered to antidote the excess of thyroid secretion (Hubert Richardson, in "Am. Medicine," August, 1906). The two observers mentioned above obtained blood-serum from thyroidectomized dogs and injected it into individuals suffer-

ing from Graves's disease and claim that they noted improvement. In two of their patients, however, tetany developed. Lanz has used the milk of thyroidectomized goats instead of the serum of thyroidectomized dogs. The serum of thyroidectomized sheep, powder made from the dried goiter of a cretin, and the powdered flesh of thyroidectomized sheep have been used (Hubert Richardson, "Am. Med.," August, 1906). What is known as *thyroidectin* is the dried serum of an animal from which the thyroid gland has been removed. John W. Rogers and S. P. Beebe have made some extremely interesting studies on the production and application of a serum. Rogers makes two sera, using one or the other, according to the needs of the case. One serum, called the normal serum, is obtained from sheep or rabbits after injecting them with the combined nucleoproteids and thyreoglobulin of healthy thyroids; the other, called the pathological serum, is obtained from the animals after injecting them with combined nucleoproteids and thyreoglobulin obtained from the thyroids of Graves's disease. In one severe case I have seen rapid improvement and apparent cure follow the use of Rogers's serum. The value of serum treatment is as yet undetermined. It is certainly not free from danger and some deaths have followed its use. One cause of diverse results after the use of goat serum may be found in the fact that some of the animals were probably incompletely thyroidectomized. The goat possesses aberrant thyroids and these must be removed as well as the gland proper. Bilateral extirpation of the cervical ganglia of the sympathetic, and division of the nerve below the ganglion, have been employed, and it is alleged with benefit (Jaboulay). I have not employed the operation for this disease. Ligation of the thyroid arteries may do good. Partial thyroidectomy is the operation commonly employed in severe cases; it has cured 50 per cent. of the cases operated upon within six months. Some cases do not improve; others improve slowly and relief is only partial. It is the operation which I prefer. The Mayos have obtained a splendid series of results from this operation. It is their custom to apply the *x*-ray daily for several weeks and then to operate. In some cases thyroid intoxication follows operation. In other cases very rapid growth follows incomplete removal, and the operation seems actually to have done harm. Sudden death occasionally follows the operation. The removal of an exophthalmic goiter is difficult; the capsule and blood-vessels rupture from slight force. All cases should not be operated upon; in fact, only those cases should be operated upon in which medical treatment has proved futile, or in which there is profound toxemia or excessive dyspnea. If the operation is performed, neither ether nor chloroform should be given, as either of these agents will greatly increase bleeding and prove dangerous. Operation is to be done under local anesthesia (eucain, cocain, or Schleich's fluid). The younger Kocher reports the experience of the Berne Clinic ("Mittheilungen aus den Grenzgebieten der Medicin und Chirurgie," Bd. ix). He reports 74 cases of true exophthalmic goiter, 59 of which were operated upon. Every operation was done with the aid of local anesthesia (1 per cent. cocain). In some cases partial thyroidectomy was performed; in some the thyroid arteries were ligated; in 3 cases not only were the arteries tied, but the sympathetic ganglia were resected. In these 59 cases were 4 deaths within ten days from tetany, and in 39 of the cases there were marked disturbances (tremor, irregularity and palpitation of the heart, vomiting, sweating, and elevated temperature). These abnormalities

were possibly due to forcing diseased thyroid secretion into the circulation. Forty-five of the 59 cases were cured and 8 were greatly improved. In 3 of the fatal cases autopsy was made, but did not disclose the cause of death. Kocher believes in operation. He thinks, however, it removes but one element of the disease, and that medical treatment may remove the others. He ad-

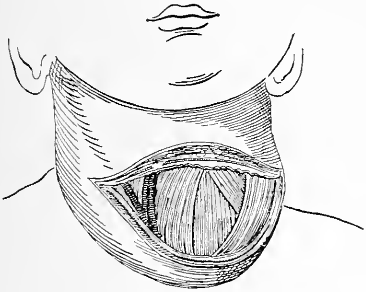


Fig. 639.—Kocher's transverse incision exposing the muscles and median veins of the neck (Kocher).

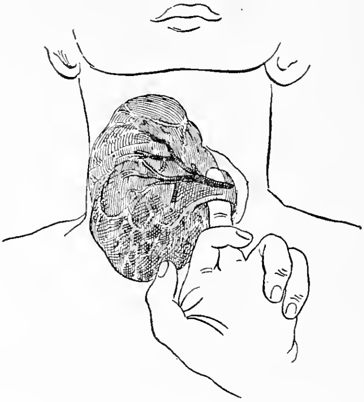


Fig. 640.—Isolating the accessory veins (Kocher).

vises strongly against operation during an exacerbation unless relief has been sought, but not obtained, by medical means.

Operations on the Thyroid Gland.—*Intraglandular Enucleation (Socin's Operation).*—By this operation an adenoma or cyst of the thyroid gland is removed, the encompassing glandular tissue being left in place. The capsule of such a growth is glandular tissue. The operation of enucleation

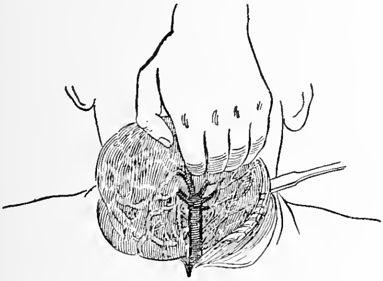


Fig. 641.—Exposure of veins at lower end before ligation (Kocher).

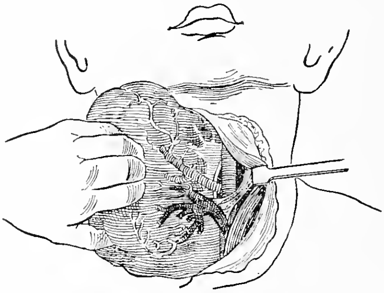


Fig. 642.—Dislocation of the goiter toward the right (Kocher).

is not suited to the removal of multiple tumors and it cannot be performed for parenchymatous goiter or exophthalmic goiter. Intraglandular enucleation is performed as follows: The thyroid is exposed by an oblique or by a horseshoe-shaped incision. An incision is made through the capsule of the thyroid gland and through the glandular tissue until the cyst or solid tumor

is reached. As a rule, the tumor can be recognized from the fact that its color differs from the color of the thyroid tissue. The tumor is turned out by the fingers, a special scoop, the knife handle, or a dry dissector. In some cases a cyst can be most easily evacuated if, after exposure, it is incised and emptied and its wall is then grasped with strong forceps. A solid tumor should, if possible, be removed intact. The wound is packed temporarily with gauze,

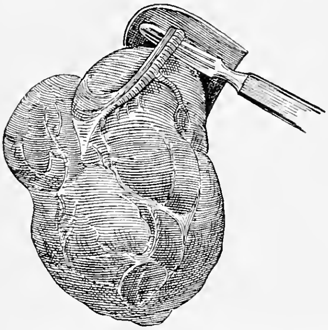


Fig. 643.—Isolation of the superior thyroid artery and vein (Kocher).

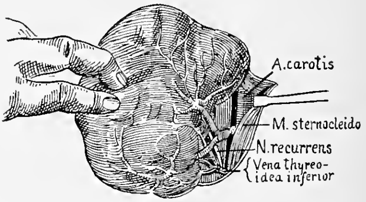


Fig. 644.—Ligation of the inferior thyroid artery (Kocher).

the edges of the cavity are grasped with forceps, the gauze is removed, and every bleeding point is carefully ligated. The wound is closed by three layers of sutures—"one in the gland, one in the muscles, and a third in the skin" (James Berry on "Diseases of the Thyroid Gland"). If the tumor is large, drain for twenty-four hours; otherwise, do not drain.

Enucleation is a very successful operation if performed upon properly

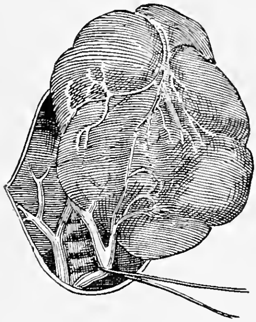


Fig. 645.—Isolation of the venæ thyreoideæ imæ (Kocher).

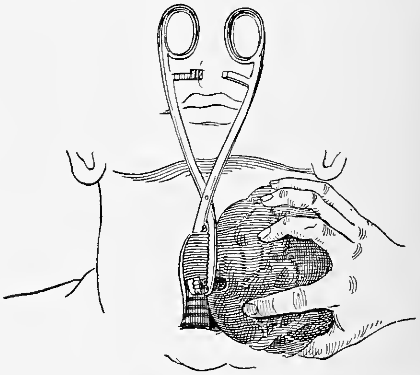


Fig. 646.—Isolation and clamping of the isthmus (Kocher).

selected cases, and can be performed rapidly, but the arrest of bleeding is often tedious and troublesome.

Extirpation.—This term means removal of the entire gland (*complete thyroidectomy*) or a portion of the gland (*partial thyroidectomy*) with the glandular capsule, the operation being an extracapsular procedure. Usually but one lobe is extirpated. This method enables the operator to tie the chief vessels before he cuts them, and as his vision is not obscured by bleeding,

he can avoid cutting the glandular capsule, which would be sure to provoke copious bleeding, and he keeps a safe distance away from the recurrent laryngeal nerve.

If the patient suffers from dyspnea, a general anesthetic is contraindicated. It is best in any case not to use one. Local anesthesia is reasonably satisfactory and is far safer. The patient is placed recumbent, with the shoulders a little raised and the neck laid upon a sand-pillow so as to throw the head back as far as is consistent with comfortable respiration.

An oblique incision, a horseshoe-shaped incision, or a transverse incision (Fig. 639) may be made. I usually employ an incision shaped like an incomplete horseshoe, the convexity being downward. Layer by layer the tissues are divided, each layer being infiltrated with the local anesthetic before it is cut. Vessels are carefully tied as divided or before division. The muscles which run from the sternum to the hyoid bone may in some cases be separated, but the extirpation of a large goiter requires transverse division of the muscles high up. The capsule of the lobe is exposed, and is separated from external parts (Figs. 640, 641, and 642). The upper portion of the gland is cleared. The superior thyroid vessels are found, tied with two ligatures each, and divided between the ligatures (Fig. 643). The clearing of the gland is carried on toward the median line and some rather large veins are encountered and tied (Fig. 645). The lower portion of the lobe is cleared and the inferior thyroid vessels are found. Near this point the recurrent laryngeal nerve can be located. If it is pressed upon or touched with a blunt instrument, the patient's voice becomes metallic. A deliberate attempt is made to locate it and the patient is engaged in a conversation requiring answers while the surgeon is investigating. The lobe is lifted from its bed and dislocated from the wound and the inferior thyroid vessels are tied close to the border of the gland in order to avoid the recurrent laryngeal nerve (Fig. 644). The vessels are tied and cut across as were the superior thyroid vessels. The isthmus is next exposed, clamped, ligated, and cut across, every care being taken to prevent colloid from being squeezed into the wound (Fig. 646). After dividing the isthmus, any bleeding point is ligated and the stump is cauterized. The divided muscles are sutured with catgut, a drainage-tube is inserted, and the superficial wound is closed with sutures of silkworm-gut.

During any operation for goiter sudden death may occur. In some cases a general anesthetic is responsible. In others, suffocation arises from pressure upon or bending of the trachea or collapse of the trachea as the goiter is lifted from its bed. In rare cases dangerous dyspnea arises from irritation of the laryngeal nerves, and cardiac inhibition may be induced in the same manner.

Acute Thyroidism.—When colloid from the thyroid is squeezed into the wound during the operation or leaks into it later, it is absorbed and may produce serious symptoms or even death. This is most apt to happen in exophthalmic goiter. The symptoms always appear within forty-eight hours and usually within twenty-four hours. Sometimes they arise quickly after operation. In some cases in which this happens the patient never reacts from the operative shock, but develops a very rapid pulse and intense dyspnea, and dies in a few hours. In less severe cases there is a period of circulatory excitement, dyspnea, and elevated temperature (*thyroid fever*). The surgeon seeks

to prevent acute thyroidism by limiting leaking of colloid, by cauterizing the stump, by washing the wound with adrenalin solution, suturing the capsule over the raw stump of the gland, and inserting drainage.

XXXIII. DISEASES AND INJURIES OF THE LYMPHATICS.

Wounds, Ruptures, and Occlusions of the Left Thoracic Ducts.—It was long believed that wounds of any part of the thoracic duct were almost certainly fatal. It is now known that wounds of the duct at the root of the neck are rarely very dangerous unless the duct is divided close to the vein. A wound of the duct is rarely seen as the result of an accident because the adjacent vital structures are apt to be injured at the same time and death rapidly ensues. Wounds of the duct or of its large branches occasionally, but very rarely, are inflicted during surgical operations. Benetau speaks of 12 cases thus inflicted; in 8 cases the operation was for tuberculous glands, in 3 for malignant glands, and in 1 for ligation of the subclavian artery. One alleged danger of wound of the duct is entrance of air into the adjacent vein. This is said to have happened in one case. As a rule, the short end of the cut duct does not bleed, the duct valves preventing hemorrhage. In Fullerton's case, when a grooved director was passed along the stump of the duct and by way of a terminal into the vein, blood at once appeared. In most cases the injury is not recognized at the time, but later, when white fluid escapes from the wound. The discharge may continue or may cease spontaneously. If it continues, there is rapid loss of flesh and strength. I assisted Dr. Keen in the case in which he did recognize the wound at the time it was inflicted. A thin fluid was observed flowing rhythmically from a tear in the duct. It is to be remembered that the course of the cervical part of the duct is very variable and sometimes the duct lies very high above the clavicle. There was 1 death in 17 recorded cases (Dudley P. Allen and C. E. Briggs, in "Amer. Med.," Sept. 21, 1901).

The discharge from a cut duct may continue to leak—perhaps a pint or more flows out during twenty-four hours. If leakage continues, constitutional effects will sooner or later become evident. In Schoff's case ("Wien. klin. Woch.," Nov. 28, 1901) it was not known that the duct had been injured until the stitches were removed from the wound in the neck. The wound was found distended with chyle and Schoff packed it with iodoform gauze. Fifteen days later the patient died from chylothorax and pulmonary compression.

Rupture of the thoracic duct or of the receptaculum chyli may occur from traumatism or be a secondary consequence of tuberculosis or carcinoma. Rupture leads to death by starvation, or to fatal compression by the exuded fluid (Harvey W. Cushing, in "Annals of Surgery," June, 1898). Occlusion of the main duct may be followed by rupture of the receptaculum chyli. Gradual occlusion by a tuberculous or inflammatory growth may not produce any serious symptoms. Cushing assumes that in such a case the lymph-current is reversed and is taken up by the right thoracic duct. In gradual obstruction masses of dilated lymph-vessels may be found, particularly in the thorax and abdomen. If lymph-vessels rupture, chyle flows out and, according to the situation, there arises "chylous ascites, chylothorax, chyluria, or chylous diarrhea" (Harvey W. Cushing, "Annals of Surgery," June, 1898).

Treatment of Wounds.—If the wound in the neck does not completely divide the duct, and if the duct wound is discovered at the time of operation, suture the duct. Allen sutured the duct and had no further leakage. Keen sutured the duct and recovery followed. If the duct is completely divided, follow Cushing's advice: "It would seem advisable to place a provisional ligature about the duct on the proximal side of the wound, and to control the leakage, if possible, by a gauze tampon. This would act as a safety-valve, and allow chyle to escape, if the pressure in the duct became too great and there was difficulty in establishing a collateral lymphatic circulation. The patient meanwhile should be given a meager diet. If the leakage should become uncontrollable and threaten starvation, the provisional ligature should be tied, with the hope of a final readjustment of collateral circulation or trusting in the presence of some anomalous anastomotic branch which might suffice to carry the lymph into the venous circulation" ("Annals of Surgery," June, 1898). Fullerton tied both ends of a divided duct and the patient recovered ("Brit. Med. Jour.," June 16, 1906). Deanesley ("Lancet," Dec. 26, 1903) inserted the divided duct into the internal jugular vein and sutured it in place. There was some leakage, but recovery ensued. After ligation the duct on the proximal side of the ligature may distend greatly and may actually rupture. When a wounded duct is leaking, the patient should be fed exclusively on proteids. The diet should be scanty and the patient must be kept absolutely quiet in order to keep pressure in the duct at as low a level as possible during the establishment of a collateral lymphatic circulation (Fullerton).

Lymphangitis is inflammation of lymphatic vessels. *Reticular* or *capillary* lymphangitis, which is inflammation of lymphatic radicles, is seen in some circumscribed inflammation of the skin. It is apt to attack the hands, causing redness and swelling, fading at the point of initial trouble while it spreads at the periphery; it is caused by micro-organisms derived from decomposing animal matter (Rosenbach). Erysipelas also causes it (see Erysipelas). *Tubular* lymphangitis, which is due to the entry into the lymphatic ducts of virulent micro-organisms or toxic materials, is seen after the infliction of dissecting-wounds, septic wounds, snake-bites, etc. It is announced by edema and by minute, hard, red streaks running from the wound up the extremity. Suppuration may occur.

Septic or infective lymphadenitis, or inflammation of the glands, may follow lymphangitis or may be due to the deposition of infective material, the lymph-vessels not being inflamed. In this form of lymphadenitis there are pain, tenderness, and swelling; in severe cases there are a chill and a septic fever. Suppuration way arise. The *treatment* is to drain and asepticize the wound, to apply iodin, blue ointment, or ichthyol over the glands and vessels, and to employ rest, heat, and compression. Internally, milk-punch, quinin, and nourishing diet are required. If the glands do not rapidly diminish in size after disinfection of a wound, and if they are in an accessible region, extirpate them. If suppuration of the glands occurs, incise and drain.

Acute lymphadenitis, or acute inflammation of the lymphatic glands, may be due to tubercle, syphilis, glanders, cold, or traumatism. Suppuration may or may not occur. In inflammatory lymphadenitis there are pain, heat, and nodular swelling. In severe cases there is fever.

The *treatment* is to asepticize any area of infection, place the glands at

rest, apply heat and ichthyol ointment, or inject into the gland every day 5 minims of a 3 per cent. solution of carbolic acid to prevent suppuration. If the glands do not rapidly shrink, extirpate them. If pus forms, evacuate it, drain, and asepticize.

Chronic lymphadenitis is almost invariably syphilitic or tuberculous. It requires constitutional treatment and the local use of ichthyol, iodin, or blue ointment. If these remedies are not rapidly successful, tuberculous glands should be removed, but syphilitic glands will rarely require such radical treatment.

Lymphangiectasis (*varicose lymphatics*), or dilatation of the lymphatic vessels, is due to obstruction. Many external causes may produce obstruction; for instance, the removal or suppurative annihilation of a considerable group of lymphatics; pressure of a scar or of a new-growth upon lymph-vessels; tuberculosis or neoplasm of a group of glands. In many cases of external pressure upon lymphatics there is no lymphangiectasis because the lymph finds other channels. In fact, it has been proved that ligation of a large lymphatic trunk is not of necessity followed by lymphangiectasis. Even when the condition arises from external pressure, it is usually temporary, although, particularly if glandular tumors exist, it may be permanent.

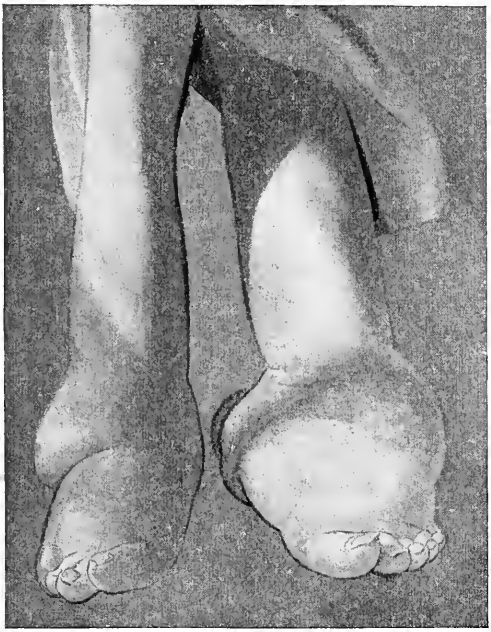


Fig. 647.—Elephantiasis. No filariæ found. Born and lived in Philadelphia.

The persistent cases are usually due to obstruction within the ducts, for instance, endothelial proliferation as a result of chronic lymphangitis, or recurrent attacks of acute capillary lymphangitis (erysipelas) or ordinary acute lymphangitis; or tuberculosis and other chronic infections. There may be such a condition as primary intralymphatic endothelial proliferation ("Med. Record," Sept. 6, 1902). Blocking with *filarial worms* may occur, and if it does, the lymphangiectasis is usually situated in the pubic, the inguinal, or the scrotal region, or on the inner side of the thigh. There are two forms: the *varicose*, in which the vessels have a tortuous outline, like varicose veins, but are covered only with surface epithelium; and *lymphatic warts* (*lymphangioma circumscriptum*), in which wart-like masses spring up, these masses being covered with epithelium and filled with lymph. In most cases of lymphangiectasis there is considerable hard edema. Periodic attacks of pain and redness occur in the area of disease, and usually at such

times fever develops. Rupture of the dilated vessels causes a flow of lymph (*lymphorrhea*). Infection and erysipelas are apt to occur; it may be over and over again. It is uncertain whether these repeated attacks of erysipelas cause and maintain or are predisposed to by lymphangiectasis.

Treatment.—If the entire area can be removed, it should be extirpated. Maitland ("Brit. Med. Jour.," Jan. 25, 1902) shows that many varices are local and can be removed. If the varices are only partially removed, lymphorrhea will probably develop.

Lymphangioma is an advanced stage of lymphangiectasis (page 315).

The **treatment** in mild cases is to pierce each vesicle with the negative pole of a galvanic battery and pass a current. In severe cases destroy the mass with the Paquelin cautery or excise it with a knife or with scissors.

Elephantiasis. — *True* elephantiasis (elephantiasis arabum) is chronic hypertrophy of the skin and subcutaneous tissues following upon a lymphangiectasis produced by a nematode worm (the filaria sanguinis hominis).

Spurious elephantiasis (Fig. 647) is hypertrophy of the skin and subcutaneous tissue due to chronic inflammation (for instance, in a leg which possesses an ancient ulcer, or in the scrotum of a man with urinary fistula).

The **treatment** is massage and bandaging, sometimes ligation of the artery of supply, extirpation, or amputation.

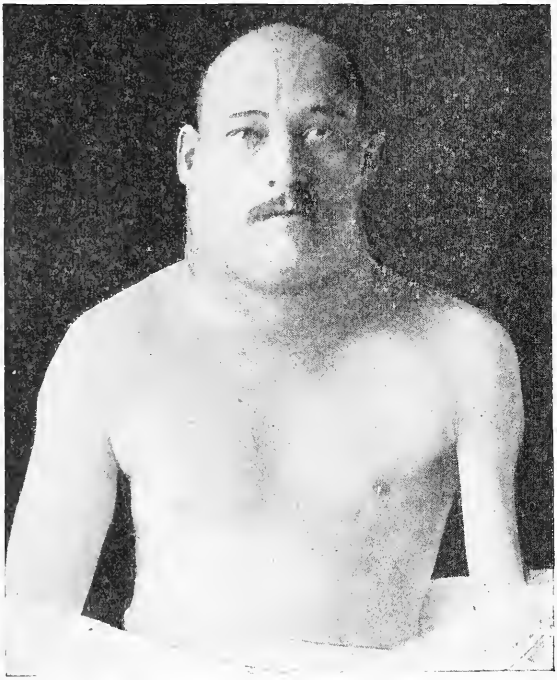


Fig. 648.—Hodgkin's disease.

Tuberculous Glands.—(See page 232.)

Lymphadenoma (*Malignant Lymphoma; Hodgkin's Disease; Pseudoleukemia*).—The term lymphoma is used loosely to designate any persistent swelling of a lymphatic gland or glands. Lymphadenoma means a swelling of lymph-glands or lymphadenoid tissue, which swelling is progressive in character, involves group after group of glands, is associated with anemia, and often accompanied by secondary growths in the abdominal viscera. Figs. 648 and 649 exhibit cases of Hodgkin's disease.

This disease is most common in those under forty, and affects males far more frequently than females. In many cases the disease arises slowly in apparently healthy glands, and exists for some time before it takes on signs

of malignancy and invades distant glands. A gland enlarged from irritation or from tuberculous disease may become lymphadenomatous, and tubercle bacilli can sometimes be found in lymphadenomatous glands. Lazarus asserts that the disease is lymphosarcoma and the tuberculosis accidental. Musser, Sternberg, and others believe that tuberculosis is the disease. It is possible that Hodgkin's disease is a form of tuberculosis of the lymphatics. In some cases the disease has a tendency to generalization from the start; in others it appears to remain localized for many months.

Symptoms.—The glands in the neck are usually involved first, but the disease may begin in the axillary glands, the thoracic glands, or the intra-abdominal glands.

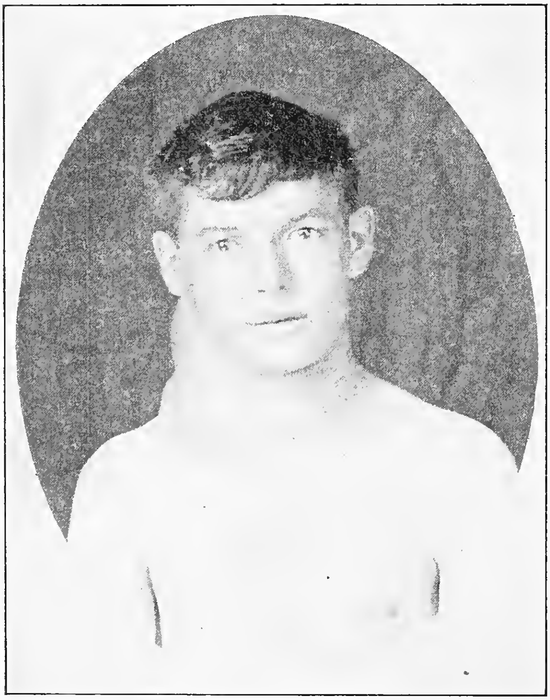


Fig. 649.—Hodgkin's disease.

Two or more regions are sometimes involved simultaneously or almost simultaneously.

When the disease begins in the neck, it affects at first one side, and after many weeks or months the other side becomes involved. The glands are at first hard, separated from each other, movable, and the skin moves freely over them. Later the large glands weld together and form great masses upon both sides of the neck and in the axillæ which may obstruct respiration.

After a time a very large mass may soften, and in very rare cases the skin becomes adherent and finally breaks. Intrathoracic symptoms point to involvement of the thoracic glands. It may be possible to palpate enlarged abdominal glands.

The spleen is enlarged; the thyroid may be enlarged; anemia is usually but not invariably present, and if it exists, there are the ordinary symptoms which go with it, viz., palpation, breathlessness, indigestion, vertigo, headache, pallor, and sometimes epistaxis. Occasionally, without obvious reason, the glands suddenly increase in size, or rapidly undergo a notable but temporary diminution.

Slight fever exists at times in almost all cases, and ague-like paroxysms may occur. During the existence of fever the glands usually increase rapidly in size.

Diagnosis.—In a wide-spread case the diagnosis is easy; in a localized case it is difficult. True tuberculous glands are most apt to first appear in the submaxillary triangle; lymphadenomatous glands, in the root of the neck or in the occipital triangle. Tuberculous adenitis is most common in children. As a rule, tuberculous glands caseate, but they may remain localized for years if caseation does not occur. The tuberculous glands usually soon become adherent and immovable. Lymphadenoma is most common after twenty, rarely remains localized for more than a few months, rarely softens unless very large, and the glands are separated and movable until a huge mass forms. Early softening, prolonged limitation to one region, and absence of pronounced anemia in a person under twenty point to tubercle. In doubtful cases a gland should be removed for microscopical and bacteriological study.

Prognosis.—The disease is almost always, if not invariably, fatal. Most cases die within three years, some die within six months, some few live four or five years or more.

Treatment.—If the glands are localized to one side of the neck, or even to both sides of the neck, remove them. Early removal before dissemination has occurred may possibly save the patient. If early or radical removal is not possible, do not operate, but treat the patient with nutritious food, tonics, courses of arsenic, and the *x*-rays. Efforts are now being made to obtain a curative serum.

XXXIV. BANDAGES.

A BANDAGE is a fibrous material which is rolled up and is then employed to retain dressings, applications, or appliances to a part, to make pressure, or to correct deformity. It may be composed of flannel, of calico, of unbleached muslin, of plain gauze, of gauze infiltrated with plaster-of-Paris or soaked in silicate of sodium, or of gauze wet with corrosive sublimate solution. Unbleached muslin, which is the best material for general use, is washed to remove the sizing, is torn into strips, and the edges are stripped of selvage. One end is folded to the extent of six inches, this is folded upon itself again and again until a firm center is formed, and over this center the bandage is rolled. In a well-rolled bandage the center cannot be pushed out of the roll. A roller bandage is divided into the initial end, which is within the roll, the body or rolled part, and the terminal end, which is free. In applying a bandage the outer surface of the terminal end is first laid upon the part.

A *cylindrical* part of the body may be covered by a *circular* bandage, each turn exactly covering the previous turns. A *conical* part may be covered by a *spiral* bandage, each turn ascending a little higher than the previous turn. As each turn of a spiral bandage is tight at its upper and loose at its lower edge, the *reverse* was devised to correct this inequality; hence a conical part should be covered by a *spiral reversed* bandage. To make a reverse, hold the roller in the right hand, start the bandage obliquely upward (do not have more than six inches of slack), place the thumb across the fresh turn, fold the bandage down without traction, and do not make traction until the turn has been carried well around the limb. A projecting point is covered with *figure-of-eight* turns. The groin, shoulder, breast, or axilla can be covered by figure-of-eight turns, each succeeding turn ascending and covering two-thirds of the previous turn and forming a figure like "the leaves on an ear of corn." Such a figure is called a "spica." In bandaging an extremity the peripheral turns should be tighter than the turns nearer the body. Never apply a tight bandage to the leg or the arm without including the foot or the hand. In firm dressings of the forearm and arm it is well to leave the ends of the fingers exposed, and use them as an index of the condition of the circulation in the part. In firm dressings of the leg and thigh leave the toes exposed.

Spiral Reversed Bandage of the Upper Extremity.—To apply this form of bandage use a roller two and a half inches wide and eight yards long. Take a circular turn about the wrist, and a second turn to hold the first; pass obliquely across the back of the hand to the extremities of the fingers; ascend the hand to the root of the thumb by several spiral turns; cover the wrist by ascending figure-of-eight turns; ascend the forearm by spiral reversed turns; cover the elbow by a figure-of-eight, and the arm by spiral reversed turns; end the bandage by two circular turns, and pin them together (Fig. 650).

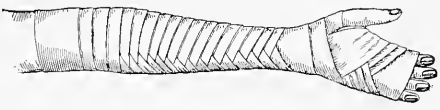


Fig. 650.—Spiral reversed bandage of the upper extremity.

Spiral Bandage of All the Fingers (Gauntlet).—The gauntlet bandage requires a roller one inch wide and three yards long. Take two circular turns around the wrist, pass obliquely across the wrist to the root of the

Fig. 651.—Gauntlet bandage.

Fig. 652.—Demi-gauntlet bandage.

thumb, and descend to its tip by spiral turns; cover in the thumb by ascending spiral turns, and return to the wrist. Cover successively each finger in the same manner, and terminate by two circular turns around the wrist (Fig. 651).

Spiral Bandage of the Palm or Dorsum of the Hand (Demi-gauntlet).—The demi-gauntlet requires a roller one inch wide and three yards long. This bandage has only a limited value; it must not be applied tightly, as it makes much pressure at the finger-roots, but leaves the fingers free. If it is desired to cover the palm, supinate the hand; if to cover the dorsum, pronate the hand. Take two circular turns around the wrist, sweep around the root of the thumb, and return to the point of origin. Treat each finger in the same way. End by circular turns around the wrist (Fig. 652).

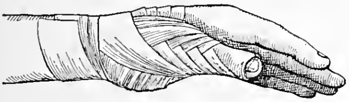


Fig. 653.—Spica of the thumb.

Spica of the Thumb.—For this bandage use a roller one inch wide and three yards long. Start at the wrist, and reach the tip of the thumb as in applying a spiral bandage of a finger. Make a series of ascending figure-of-eight turns between thumb and wrist, each ascending turn overlying two-thirds of the previous turn; terminate with a circular of the wrist (Fig. 653).

Selva's Thumb Bandage (Fig. 654).—Lay the terminal end of the bandage on the outer side of the second phalanx of the thumb, near the base of the phalanx. Carry it over the palmar side of the pulp of the last phalanx to the inner side of the second phalanx. The surgeon holds this turn in place with his left thumb and index finger. The roller is returned in a recurrent manner to its place of origin, overlaps the preceding turn, and is placed as much as possible on the dorsum. The roller is carried over the dorsum

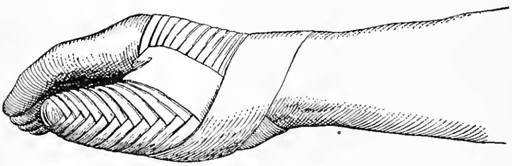


Fig. 654.—Selva's thumb-bandage applied.

of the terminal phalanx and is turned around the tip, the loop crossing over the center of the nail. Figure-of-eight turns are now made over the dorsum of the hand, over the palm, and returning to the terminal phalanx, and an ascending spica is made.*

Spiral Reversed Bandage of the Lower Extremity.—Take a roller two and a half inches wide and seven yards long, and make two circular turns just above the malleoli, and an oblique turn across the dorsum of the foot to the metatarsophalangeal articulation; make a circular turn, and cover the foot with ascending spiral reversed turns; return to the ankle by a figure-of-eight; ascend the leg by spiral reverses; cover the knee by a figure-of-eight, and the thigh by spiral reverses; terminate by two circular turns (Fig. 655).

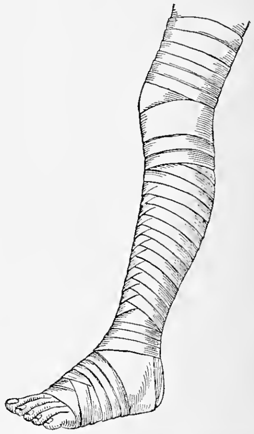


Fig. 655.—Spiral reversed bandage of the lower extremity.

Bandage of the Foot Covering the Heel (American Bandage of the Foot).—Take a roller two and a half inches wide and seven yards long. The bandage is begun as is a spiral reversed bandage of the lower extremity. After the foot is well covered by ascending spiral reversed turns carry the bandage directly around the point of the heel and return to the instep; from this point carry it around the back of the ankle, down the side of the heel, under the heel, up to the instep, around the ankle in the opposite direction, down the opposite side of the heel, and under the heel and up to the instep; take the roller to above the malleoli, and end by a circular turn (Fig. 656).

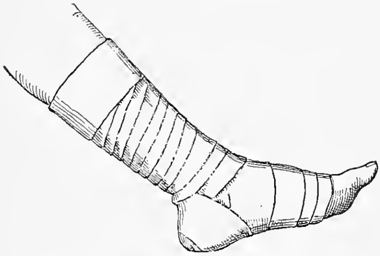


Fig. 656.—Method of covering the heel.

Bandage of the Foot Not Covering the Heel (French Method).—Take a roller two and a half inches wide and six yards long. Make a spiral reversed bandage of the foot and a figure-of-eight of the ankle-joint (Fig. 657).

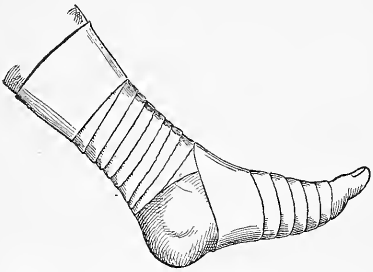


Fig. 657.—Figure-of-eight bandage of the ankle.

Fig. 658.—Spica of the instep.

Spiral Bandage of the Foot Covering the Heel (Ribbail's Bandage; Spica of the Instep).—Take a roller two and a half inches wide and six yards

* Medical News, Sept. 28, 1895.

long. Apply as a spiral reversed bandage of the lower extremity until the metatarsus is well covered. Carry the bandage, parallel with the margin of the foot (the inner or outer margin, according as to whether it is the left foot or the right), around the posterior aspect of the heel, along the opposite margin of the foot to cross the original turn at the median line of the dorsum. Make a number of these ascending turns, each turn covering in three-fourths of the previous turn; terminate by circular turns above the ankle (Fig. 658).

Crossed Bandage of Both Eyes (Figure-of-eight of Both Eyes).—Take a roller two inches wide and six yards long. Make a circular turn around the forehead from right to left, a second turn to hold the first, a turn downward over the left eye, under the left ear, around the back of the neck, and upward under the right ear and over the right eye; repeat these turns, and terminate by a circular turn of the forehead (Fig. 659).

Barton's Bandage (Figure-of-eight of the Jaw and Occiput).—Take a roller two inches wide and five yards long. Place the initial extremity of the bandage behind the inion; pass over the right parietal bone, across the

Fig. 659.—Crossed figure-of-eight bandage of both eyes.

Fig. 660.—Barton's bandage or figure-of-eight of the jaw.

vertex, down the left side in front of the ear, under the chin, up the right side in front of the ear, across the vertex, and across the left parietal bone to the point of origin. A turn is now taken forward along the right side of the jaw to the chin, and backward along the left side of the jaw from the chin to the nape of the neck; repeat these turns, and pin the points of junction (Fig. 660). In Barton's bandage the ear lies in an uncovered triangle. The bandage may be finished by circular turns around the forehead. Barton's bandage is used for fracture of the lower jaw.

Borsch's eye-bandage is convenient and useful (Fig. 661). A narrow bandage is laid along the head and permitted to hang down the face in front of the sound eye. A circular bandage is applied around both eyes and over the narrow bandage (A). The narrow strip is lifted and pinned, and the sound eye is thus uncovered. Of course, the posterior end of A should first be pinned to the circular turn.

Gibson's Bandage.—Take a roller two inches wide and six yards long. Make three vertical turns around the head and the jaw in front of the ear;

reverse the bandage above the level of the ear, and carry it horizontally around the forehead and head three times; drop the bandage to the nape of the neck, and take three turns around the neck and jaw; terminate by taking from the nape of the neck a half turn upward, carrying the bandage forward to the forehead, and pinning it over the neck and over the forehead.

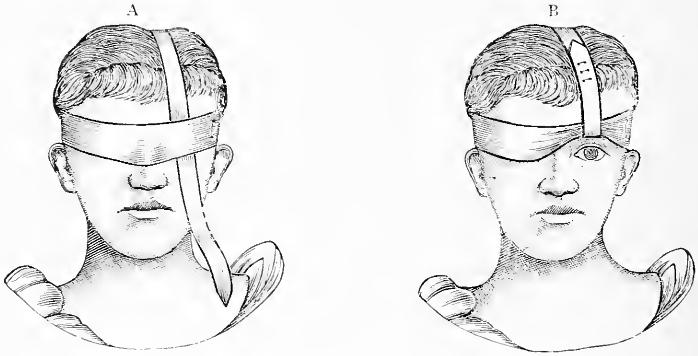


Fig. 661.—Borsch's eye-bandage: A, First step; B, second step.

Pin each point of junction (Fig. 662). Gibson's bandage is used for fracture of the lower jaw.

Crossed Bandage of the Angle of the Jaw (Oblique Bandage of the Jaw).—Take a roller two inches wide and six yards long. Make a circular turn around the forehead toward the affected side, and a second turn to hold the first; take the turn to the back of the neck; carry it forward on the sound side, under the ear and chin; now make a series of turns around the head and jaw, in front of the ear on the injured side, but back of the ear

Fig. 662.—Gibson's bandage.

Fig. 663.—Oblique or crossed bandage of the angle of the jaw.

on the sound side: these turns successively *advance* on the injured side only; terminate by going backward under the ear of the sound side to the nape of the neck, and then by taking two circular turns around the forehead (Fig. 663). This bandage is used for fractures of the ramus of the jaw and for holding dressings upon the face and the cranium.

Spica of the Groin (Figure-of-eight of the Thigh and Pelvis).—For one groin the roller is three inches wide and seven yards long; for both groins, three inches wide and ten yards long. Take two circular turns, from right to left, around the waist, then down over the front of the right groin, around the back of the thigh, up over the front of the right groin, around the waist, down over the front of the left groin, round the back of the thigh, up over the left groin, and around the waist. The map being thus laid out, the

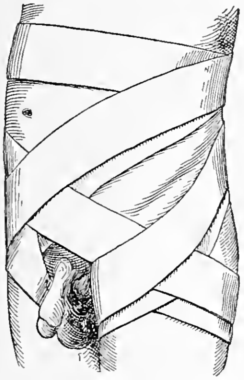


Fig. 664.—Spica of the groin.

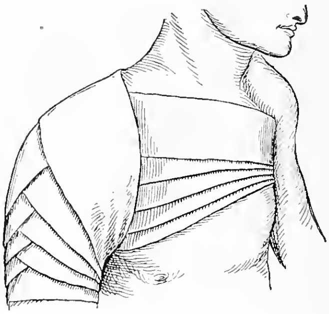


Fig. 665.—Spica of the shoulder.

turns are continued and ascended, each turn overlying one-third of the previous turn, and the bandage is completed by a circular turn around the waist (Fig. 664). Pin the crossed pieces.

Spica of the Shoulder.—Take a roller two and a half inches wide and seven yards long. Make a circular turn and several spiral reversed turns around the upper arm; then, coming from behind forward, carry the bandage over the shoulder, across the front of the chest, through the opposite arm-pit, and return across the back to the shoulder. Make successive and advancing turns (Fig. 665).

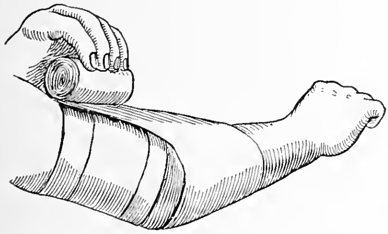


Fig. 666.—Figure-of-eight bandage of the elbow.

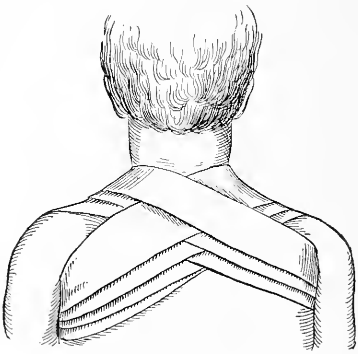


Fig. 667.—Posterior figure-of-eight of both shoulders.

Figure-of-eight bandages of the elbow, both shoulders (posterior figure-of-eight), the neck and axilla are shown in Figs. 666, 667, and 668. A figure-of-eight of the breast is shown in Fig. 673.

Velpeau's Bandage.—Take a roller two and a half inches wide and

ten yards long. Place the palm of the hand of the injured side upon the shoulder of the sound side, interposing cotton between the arm and the side. Start the bandage at the axilla of the sound side posteriorly, carry it across the back to the shoulder of the injured side, down the front of the arm and under the arm just above the elbow, returning to the point of origin; repeat this turn, but, on reaching the axilla the second time, cross the back and pass around the chest, including the arm; keep on with these turns,

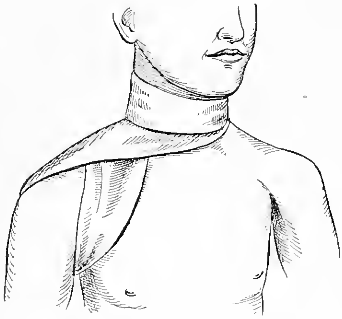


Fig. 668.—Figure-of-eight of neck and axilla.

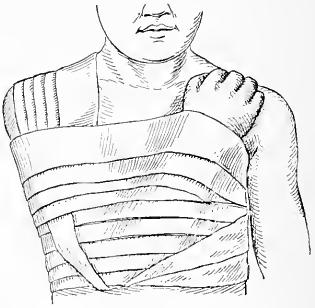


Fig. 669.—Velpeau's bandage.

each alternate turn going over the injured clavicle, each alternate turn encircling the arm and the body, the first turns advancing and the second turns ascending (Fig. 669). Pin the crossed pieces. This bandage is used for fracture of the clavicle.

Desault's Apparatus.—This apparatus consists of three rollers, a pad, and a sling. Each roller is two and a half inches wide and seven yards long.

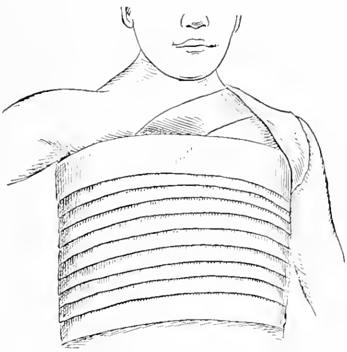


Fig. 670.—Desault's bandage, first roller.

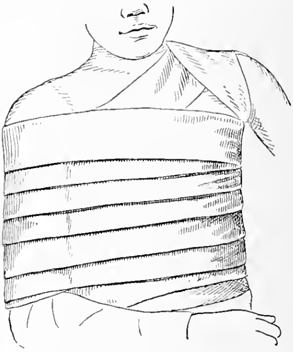


Fig. 671.—Desault's bandage, second roller.

The pad, which is wedge-shaped, is inserted into the axilla with the base up. The *first roller* is used to hold the pad (Fig. 670). The *second roller* binds the arm to the side over the pad. This pad is a fulcrum, the shoulder is the weight, the arm is the lever, and the second roller of Desault corrects the inward deformity of a fractured clavicle (Fig. 671). The *third roller* corrects the downward and forward displacement. It starts in the axilla of the sound side anteriorly, crosses the chest to the shoulder of the injured

side, runs down the back of the arm, around the elbow, and crosses the chest to the point of origin, forming the anterior triangle; it is now carried through the axilla of the sound side to the back, crosses the back to the shoulder of the injured side, runs down the front of the arm, around the elbow, and across the back to the axilla of the sound side, forming the posterior triangle (Fig. 672). The formula for the Desault bandage is: start in the axilla of the sound side anteriorly, run from the axilla to the shoulder, from the shoulder to the elbow, from the elbow to the axilla, and pass to the back; from the axilla to the shoulder, from the shoulder to the elbow, from the elbow to the axilla, and pass to the front. Pin the crossed pieces and hang the hand in a sling (Fig. 672).

Recurrent Bandage of the Head.—Take a roller two inches wide and six yards long. Make two circular turns horizontally around the forehead and head; when the middle of the forehead is reached, catch the bandage, take a half turn, carry the bandage to the occiput, let an assistant catch it, take a half turn, bring the roller forward to the forehead, covering a portion of the preceding turn; continue this process until the scalp is well covered;

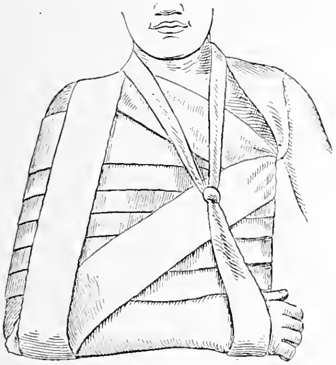


Fig. 672.—Desault's bandage, third roller.

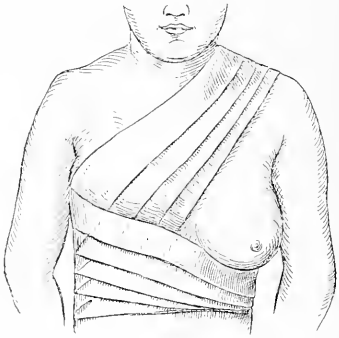


Fig. 673.—Figure-of-eight bandage of the breast.

terminate with two circular turns around the forehead and head (Fig. 674). It is often advisable to take a turn around the head and chin. Pin the crossed pieces.

Recurrent Bandage of a Stump.—Take a roller two inches wide and six yards long. Make two light circular turns around the root of the stump; make recurrent turns covering the stump as is done in covering the head; take a circular turn around the root of the stump, oblique turns to the top of the stump, circular turns around the tip, and apply an ascending spiral reversed bandage (Fig. 675).

T-Bandage of the Perineum.—Pass the transverse part around the body above the iliac crests, and pin it in front; bring one of the tails over the dressing and up between the thigh and the genitals of one side, and the other tail over the dressing and up between the thigh and the genitals of the opposite side; secure these tails to the horizontal band.

Handkerchief Bandages.—Take unbleached muslin one yard square. The muslin folded once makes an *oblong* bandage; bringing its diagonal angles together makes a *triangle* bandage; a *cravat* is formed by folding a

triangle bandage from summit to base; a *cord* is a twisted cravat. The triangle makes an admirable sling.

Fixed Dressings.—Plaster-of-Paris Bandage.—Cover the extremity with a cotton or flannel bandage or with a woolen stocking. Take a gauze roller infiltrated with plaster and place it endwise in a basin of tepid water, the water covering the plaster. When bubbles cease to arise, squeeze the bandage and apply it *without much tension*, smoothing out each turn with a moistened hand. As each bandage is taken from the basin drop a fresh one into the water. Apply four thicknesses of bandage, and finish the dressing by sprinkling dry plaster over the bandage and smoothing it with wet hands. The ordinary plaster will set in from fifteen to thirty minutes. If it is desired to have it set more rapidly, put a tablespoonful of salt in each pint of water used; if to have it set more slowly, pour stale beer into the water. The plaster bandage is removed by sawing it down the front or by moistening with dilute hydrochloric acid and then cutting through the moistened line with a strong knife. Gigli has devised a mode of application which

Fig. 674.—Recurrent bandage of the head.

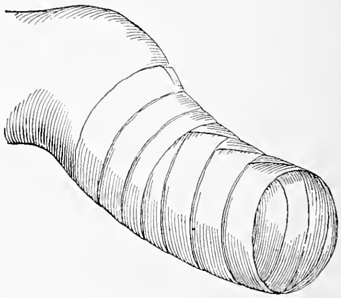


Fig. 675.—Recurrent bandage of a stump.

enables us to remove the dressing with ease. A layer of cotton is placed around the limb. A piece of parchment paper which has been wet and shaken out is placed over the cotton. A cord greased with vaselin is laid upon the paper in a position corresponding to the line we will wish to saw through the plaster. Apply the plaster bandage and see that the ends of the cord project beyond the bandage. When desiring to remove the bandage take a steel wire, make nicks on one side of it by means of a file, and attach the string to the wire. Pull the wire under the bandage. Attach each end of the wire to a wooden handle and saw through the plaster.*

Silicate of Sodium Dressing.—Protect the part as is done for a plaster bandage. Bandage the limb *loosely* with an ordinary gauze bandage, paint this bandage with silicate of sodium, apply another bandage and paint it, and so on until six layers are applied. Gauze bandages are better than ordinary bandages to take up silicate of sodium. Silicate dressings require from twelve to eighteen hours to dry, and they are removed by softening with warm water and then cutting.

* La Semaine Méd., Nov. 3, 1895.

XXXV. PLASTIC SURGERY.

Plastic surgery includes operations for the repair of deficiencies, for the replacement of lost parts, for the restoration of function in parts tied down by scars, and for the correction of disfiguring projections. Many reparative operations have been devised. Among them are: cheiloplasty, or the construction of a new lip; the closure of a cleft in the palate, the lip, or the penis; the making of a new nose; skin-grafting; grafting of muscle or tendon; nerve-grafting; the introduction of celluloid or metal into the tissues to act as supports; the injection of paraffin into the tissues to amend a de-

Fig. 676.—Injury caused by crush and burn. Healed by granulation in eight months. Showing a condition after removal of scar of the palm, which has been repaired by stitching in an autoplastic graft (free flap) from the thigh (Geo. S. Brown).

pression; the diminution in the size of a lip or a nose; the amendment of protuberant ears; the correction of distortion due to cicatrices; excision of scars; closure of congenital sinuses and of fistulæ; removal of disfiguring growths.

The subject of plastic surgery is very extensive, and a treatise upon it should be consulted if one wishes to obtain detailed and comprehensive information.

A plastic operation can be successful after lupus only when the disease has been cured. It is useless to do a plastic operation during active syphilis,

and a plastic operation for a syphilitic loss of substance is to be performed only after the patient has been thoroughly treated and the disease has been apparently cured. The first step of a plastic operation consists in making raw the surfaces which are to be brought together; the second step is the complete arrest of bleeding; the third step is the approximation of the surfaces without tension; the fourth step is to close any gap from which tissue may have been transplanted; and the final step is the application of the dressings.* The following are the methods used: †

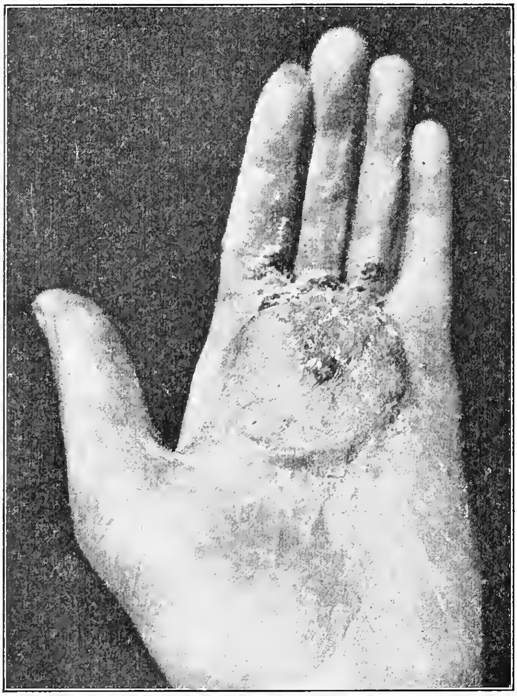


Fig. 677.—Claw-hand from burn. A flap with a pedicle was taken from the chest. The pedicle was cut on ninth day.

Displacement is the method of stretching or of sliding: (1) approximation after freshening the edges (as in harelip); (2) sliding into position after transferring tension to other localities (linear incisions to allow of stretching of the skin over large wounds). *Interpolation* is the method of borrowing material from an adjacent or a distant region or from another person: (1) *transferring a flap with a pedicle*, which flap is put in place at once or is gradually gotten into place by a series of partial operations (as in rhinoplasty, when a flap is taken from the forehead); (2) *transplanting without a pedicle*, which is performed by placing in position and by fixing there portions of tissue recently removed from the part, from another part of the same individual, or from a lower animal (as replacement of the button of bone after trephining, transplanting a piece of bone from a lower animal to remedy a bone-defect in a human being, or the grafting of a piece of nerve from a lower animal or an amputated human limb to remedy a loss of nerve in a human being in nerve-grafting, or skin-grafting). *Retrenchment* is the removal of redundant material and the production of cicatricial contraction.

Skin-grafting.—As long ago as 1847 Dr. Frank Hamilton partly covered an ulcer with a pediculated flap, and trusted that the uncovered portion would be healed by new skin from the flap. We may graft small pieces of epithelium taken from the patient, or another person, or one of the lower animals, or we may graft large pieces of epithelium. The grafts should, if possible, come from the person to be grafted. The epidermic scales may be scraped

* "American Text-book of Surgery." † *Ibid.*

off the sound skin and grafted. Lusk has blistered the skin with cantharides and grafted portions of the epidermis. The shavings of a corn have been used. The best plan is to cut off and transplant small bits of epidermis.

Grafts may come from another person or from a lower animal, but such grafts are not so apt to grow as graft obtained from the individual, and even when they do grow, fail to furnish a secure cicatrix. Frog-skin furnishes unsatisfactory grafts. Some surgeons have used bits of sponge; others the skin of rabbits, guinea-pigs, or pups. Arnot has employed the lining membrane of a hen's egg, cut in strips and applied upon the wound with the shell-surface uppermost. Small bits of epidermis taken from a recently amputated foreskin or leg may be used.

Reverdin's Method.—This operation was devised by Reverdin in 1869. Small bits of epithelium are used and they are taken preferably from the person himself. The surface to be grafted should possess healthy granulations level with the skin. Cleanse the skin from which the grafts are to come, the ulcer, and the skin about it, and, if corrosive sublimate is used, wash it away with a stream of warm normal salt solution. Thrust a sewing-needle under the epidermis to raise it, cut off the graft with a pair of scissors, and place the raw surface of the graft upon the ulcer. After applying a number of grafts, place thin pieces of gutta-percha tissue over them and extending on each side of the ulcer, and so placed as to have distinct intervals between them, the gaps permitting drainage. This tissue, after being asepticized, is moistened with warm normal salt solution. Dress with a pad of aseptic gauze moistened with salt solution; place over this gauze a rubber-dam, and over the latter absorbent cotton and a bandage. In the case of children apply a light silicate bandage. Put the patient in bed. In forty-eight hours remove all the dressings except the gutta-percha tissue, irrigate with normal salt solution, and reapply the dressings. All signs of the grafts will often have disappeared. In a day or two, at the site of grafting, bluish-white spots should appear, which are islands of epidermis. Each graft is capable of forming about half an inch of cicatrix. Grafting also stimulates the edges of the ulcer to cicatrize and contract. At the end of seven days the special dressings can be dispensed with. The spot from which the grafts are taken is dressed antiseptically. Reverdin's method does not limit cicatricial contraction to any great degree, and the new skin is apt to break down.

The Ollier-Thiersch's Method.—Ollier, of Lyons, in 1872 succeeded in transferring large pieces of epidermis. In 1886 Thiersch, of Leipzig, set forth the technic practically as it is employed to-day. The Ollier-Thiersch method is performed as follows: Thoroughly asepticize the ulcer, the surrounding skin, and the site from which the graft is to come (the inner side of the arm or the thigh), and wash away the mercurial preparation with normal salt solution. Apply dressings wet with salt solution. On bringing the patient into the operating-room remove the dressings from the ulcer, scrape the ulcer and its edges, irrigate with salt solution, and compress to arrest hemorrhage. Grafts are then obtained by putting the prepared skin upon the stretch and cutting strips with a razor. While the razor is being used the part is constantly irrigated with salt solution. Mixter's apparatus enables one to perform this operation with great neatness and speed. This apparatus consists of a knife and an open square with sharp points on the under surface.

The square is forced down upon the front of the thigh, the epidermis mounts up in the opening to above the level of the metal sides, and the grafts may be cut with ease. The graft contains the epidermis, the rete, and part of the true skin. In Halsted's clinic the skin of the thigh is made tense by pressing upon it with a piece of asepticized wood, the wood is drawn slowly along, and is followed closely by the sharp catlin, with which the surgeon cuts long grafts. The grafts are pressed into place upon the raw surface, and each graft overlaps a little the edges of the wound and the adjacent grafts. The skin-wound is dressed antiseptically, and the grafted area is dressed as in Reverdin's method. Recently it has been suggested that a ring of aseptic gauze be made to encircle the limb below the grafted area, and another ring above the grafted area; on these pads little strips of wood wrapped in aseptic gauze are so laid as to make a cage, and around this cage the dressings are applied (moist chamber plan) (Fig. 678).

Wolfe's Method.—It was pointed out by Wolfe, of Glascow, that a piece of skin, comprising the entire thickness of that structure, can be successfully transplanted without a pedicle. The ulcer is extirpated and asepticized and bleeding is arrested. The flap is cut one-sixth larger than the surface to be covered. Fat is kept out of the graft. The bit of tissue is laid upon

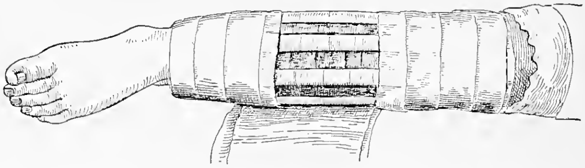


Fig. 678.—Mayer's dressing for Thiersch's method of skin-grafting ("American Text-book of Surgery").

the wound, the edges of the graft being brought against the edges of the raw area. It is not necessary to employ sutures. The part is dressed in a moist chamber. If the graft perishes, remove it.

Subcutaneous Injection of Paraffin for Prosthetic Purposes.—The principle of injecting solidifying oils into tissues to mechanically obtain effects was first laid down by J. Leonard Corning in 1891. The use of paraffin was introduced by Gersuny to amend the deformity of a saddle-nose. It has been used to limit incontinence of feces, incontinence of urine in women, to prevent reunion of nerves after division, to replace a testicle, to obliterate smallpox marks, to narrow a hernial ring, to correct sinking of the cheek after removal of the upper jaw, and for other purposes (Moszkowicz, in "Wien. klin. Woch.," June 20, 1901). Paraffin is not toxic. Its injection may produce some swelling and redness, but applications of cold quickly control inflammation. In two or three months the paraffin becomes hard like cartilage and encapsuled. It is questionable whether or not it is subsequently destroyed and replaced by granulation tissue. Sometimes sloughing takes place in the skin above it.

Prepare the paraffin as follows: In Gersuny's clinic solid paraffin is mixed with liquid paraffin. The melting-point of the mixture should be about 104° F. It is rendered sterile by boiling, is injected by a warm syringe, and as

a semi-solid, the skin having been first warmed by a hot sponge. After injection it is moulded into proper shape. It sets in half a minute. It is not wise to use a mixture with a much higher melting-point, because it would possibly cause thrombosis of veins.

Rhinoplasty.—The complete operation may be performed by transferring a flap from the forehead. This is known as the Indian operation. It was employed for centuries in India, and interest in it was awakened in England about 1820 by Mr. Carpue. The edges of the defect are made raw. A model of the desired nose is made out of gutta-percha, and its outlines are marked upon the forehead, and the cut is made one-quarter of an inch outside of the outline so as to allow room for retraction. The flap is turned down and sutured in place (Fig. 679), care being taken not to cut

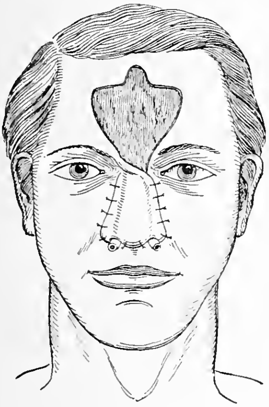


Fig. 679.—Indian method of rhinoplasty.

Fig. 680.—Italian method of rhinoplasty.

off the blood-supply in the pedicle. Plugs of gauze or tubes are inserted to support the flap.

The complete operation can be performed by the Italian method (Tagliacotian method). This method was first described in Tagliacozzi's book, which was published in 1597. In this operation the flap is marked out on the arm, is made twice the size of the desired nose, and is left attached by a broad pedicle. The nasal surface is rendered raw at proper regions, and the flap is sutured in place, the hand being held upon the head by a special apparatus (Fig. 680). The raw surface upon the arm is dressed. In about three weeks the flap is cut loose from the arm, and is pared and corrected as may be necessary.

The operations for harelip and cleft palate, and plastic operations on muscles, nerves, tendons, and bones, are considered in other portions of the work.

XXXVI. DISEASES AND INJURIES OF THE GENITO-URINARY ORGANS.

Hematuria.—By this term is meant the voiding of bloody urine or of pure blood, the blood arising from any portion of the urinary apparatus, and the condition being a symptom and not a disease. Hematuria may be a symptom of disease or of injury of some part of the urinary system, of blood-disorganizations (purpura, scurvy, or variola), or of metallic poisoning (mercury, lead, or arsenic). The color of the urine in hematuria may be anything between a light red and a decided black, but these colors may be produced by agents other than blood. Senna and rhubarb make urine red; carbolic and salicylic acids, brown or greenish-black; beet-root and sorrel, the color of blood; methylene-blue, blue. In jaundice, melanosis, and splenic fever the urine becomes brown. Be sure that bloody urine in the female is not due to admixture with menstrual blood.

Tests for Blood.—**Spectroscope Test.**—Bloody urine, if fresh and diluted with water, shows the two absorption-bands of oxyhemoglobin. The addition of ammonium sulphid causes the two bands to give place to the band of reduced hemoglobin. If bloody urine stands for some time, the four bands of methemoglobin are discovered (v. Jaksch).

Heller's Test.—Add potassium hydrate to the urine, and boil; a red precipitate of earthy phosphates and hematin forms. Throw the precipitate upon a filter and treat it with acetic acid; a red solution is produced, which soon fades.

Rosenthal's Test.—Take the precipitate from caustic potash, dry it, and test it for hematin; put some of the dry sediment on a slide, add a crystal of common salt, apply a cover-glass, and cause a few drops of glacial acetic acid to flow under the glass; warm, but do not boil. Teichmann's crystals will appear on cooling.

Struve's Test.—Test the urine with hydrate of potassium, and add acetic acid in excess; a dark precipitate forms, which will yield crystals of hematin when treated with sal ammoniac and glacial acetic acid.

Almen's Test.—Take 10 c.c. of urine, and pour upon its surface a mixture of equal parts of tincture of guaiac and old oil of turpentine; at the point of junction of this fluid with the urine there forms a white ring which turns blue.

Microscopic Test.—The microscope shows numerous corpuscles except in a very alkaline urine, when but few corpuscles may be found.

In hemoglobinuria—a condition sometimes occurring in burns, acute maladies, and metallic poisoning—there is present blood-coloring matter, which is shown by Heller's test and by Almen's test. The spectroscope shows methemoglobin. The microscope shows no corpuscles or only a few, but discloses masses of pigment.

Bleeding from the Kidney-substance.—Bleeding from the *pelvis* of the kidney and from the *ureter* may be due to inflammation, congestion, contusion, stone, vicarious menstruation, hemorrhagic diathesis, powerful diuretics, fevers, purpura, tumors, catheterization of the bladder, etc. Blood is thoroughly mixed with the urine, and no sediment forms (smoky urine).

The corpuscles are profoundly altered, are devoid of coloring-matter, and show pale-yellow rings. The severity of the hemorrhage is measured by the number of the corpuscles. Von Jaksch states that the diagnosis between renal and ureteral hemorrhage rests on the nature of the casts and the epithelium present. From the pelvis of the kidney and from the ureter comes small epithelium, the cells from the superficial layers being polygonal or elliptical, those from the deeper layers being oval or irregular. In hemorrhage from the ureter the cells are few; in hemorrhage from the pelvis they are plentiful and rest upon one another like "tiles on a roof" (v. Jaksch). Cells from the tubules of the kidney are small, granular, and polyhedral, have large nuclei, and are often so arranged as to form cylinders (epithelial casts). The urine during and immediately after a renal hemorrhage is apt to be acid unless alkalies have been administered, unless the bleeding has been

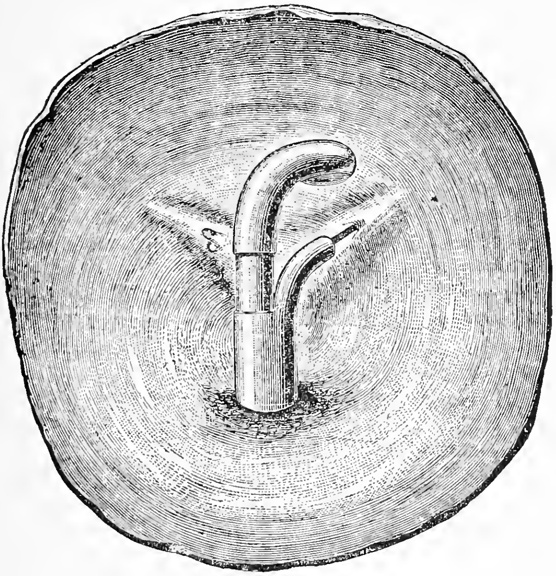


Fig. 681.—Nitze's instrument in use ("Berl. klin. Wochen.").

severe, or unless pus is present in the urine. A very large renal hemorrhage may cause the passage of almost pure blood. In *renal* hematuria there are aching in the loin, numbness of the corresponding leg, and often renal colic. The use of the cystoscope enables the surgeon to determine if the hemorrhage is vesical or renal, and if it comes from one or both kidneys. If the bladder-fluid is kept clear, the blood can be seen flowing out of the ureter of the damaged organ, or if both ureters are catheterized a sample of urine can be obtained from each kidney.

Ureter-catheterism.—Catheterization of the ureters may give information of the greatest value. It enables the surgeon to obtain the urine from one kidney unmixed with urine from the other kidney and uncontaminated by material from the bladder or urethra. By this method we can determine if pus, blood, bacilli, etc., come from the ureter or kidney, and from which

ureter or kidney. A stricture or a calculus of a ureter can be located; hydronephrosis and pyonephrosis can be diagnosticated; the presence of both kidneys, and if either kidney is diseased or if both are diseased, and the secretory capacity of each kidney in a given time, can be ascertained. The method is also employed to treat various conditions of the ureter and kidney.

Kelly impressed upon the profession that the ureters in women can be catheterized, when the patient by the knee-chest posture permits the atmospheric distention of the bladder, so that the ureteral orifices can be inspected through a speculum. Light is reflected into the speculum, a forehead mirror and an electric light being employed. It may be necessary to dilate the ureter before inserting the speculum. It is rarely necessary to give a general anesthetic. Kelly moistens a bit of cotton wrapped on a metal rod in a 10 per cent. solution of cocain, introduces it just within the external urethral orifice, and holds it there for five minutes before beginning the operation. When the ureteral orifice of one side is found by inspection through the speculum, he introduces a sterile flexible silk catheter lubricated with boroglycerid and it is pushed up from four to six inches in the ureter. A similar tube is introduced into the other ureter and the separated urines are collected in test-tubes. (See Kelly's "Operative Gynæcology.") The catheterization of the ureters by this method can be performed only by a dextrous and experienced man; but such an individual can do it with ease and celerity; as practised by Kelly himself, it seems, until one tries it, the perfection of simplicity.

The ureter-cystoscope of Bransford Lewis is an admirable instrument. It can be used upon the male or the female, and it enables the ordinary surgeon to catheterize the ureters more easily than by Kelly's method. (Fig. 683 shows Lewis's instrument.) The illumination is by a cold electric light, the bladder is distended with air, and the observer is free from the annoyance of clouding of the liquid which so commonly occurs when the bladder is distended with fluid.

The male ureter can be satisfactorily catheterized by means of the instrument of Nitze (Fig. 681).

Kelly has recently catheterized the ureter in a man by inserting a straight speculum, placing the patient in the knee-chest position to inflate the bladder with air, and introducing a metallic catheter.

Segregation of Urine.—Professor Harris, of Chicago, has devised an excellent instrument (Fig. 682) which in many cases greatly simplifies the problem of obtaining unmixed urine from each ureter. The double catheter is passed into the bladder. The lever is inserted in the rectum of the male and the vagina of the female. The lever is fastened to the perforated frame from the double catheter. The double catheter is now opened in the bladder, and the blades of the instrument are held in position by a spring. The end of the lever in the vagina or rectum humps up the floor of the bladder between the separated ends of the divided catheter, and forms a longitudinal septum or watershed between the ureteral orifices. The end of each catheter lies in the bottom of a pocket in the side of the watershed. "By producing a very slight exhaustion of the air in the vials by means of the bulb, the urine,

as fast as it escapes from the ureters, drops directly into the ends of the catheters and flows at once into the vials, right and left respectively."*

In using this instrument, place the patient flat on his back upon a table, the thighs and legs being flexed, and the feet, hips, and head being on the same level. Irrigate the bladder thoroughly with sterile water, and have

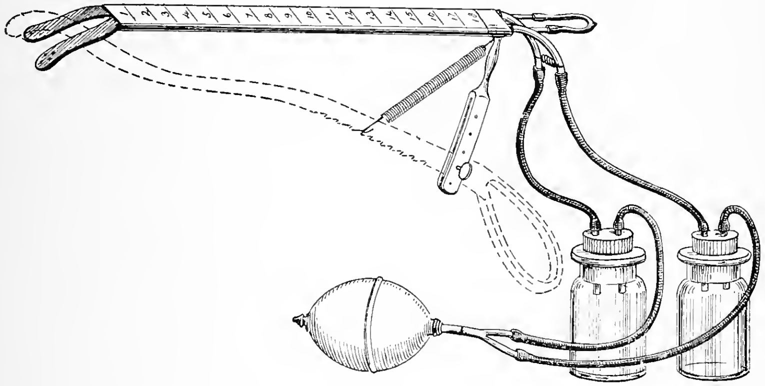


Fig. 682.—Harris's instrument fitted for use.

150 c.c. of fluid in the bladder when the blades are opened. Leave the instrument in place for thirty minutes. It is rarely necessary to give an anesthetic. In some cases cocain must be used, and in some cases of painful cystitis ether should be given. Harris says the instrument should not be used if there is a growth of the bladder that bleeds easily, if the bladder is contracted, or if there is a very large prostate or a vesical stone.†

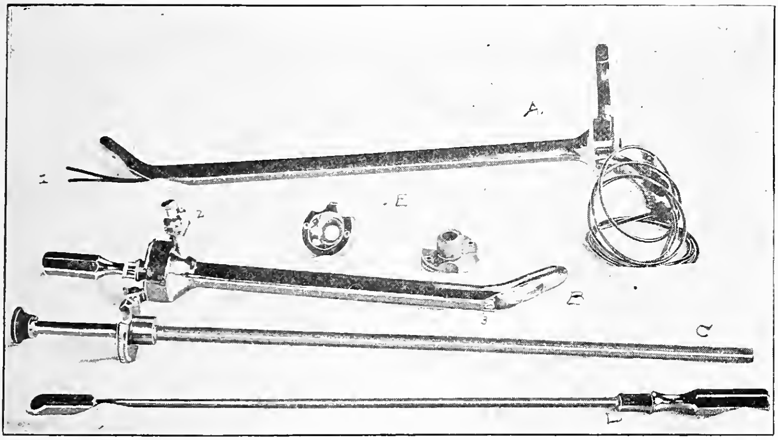


Fig. 683.—Lewis's ureter-cystoscope.

In catheterization of the ureters there is always some danger of carrying infection upward from the bladder. The Harris method of segregation is

* M. I. Harris, in Medicine, April, 1898.
† Jour. Cutan. and Gen.-Urin. Dis., May, 1899.

free from this danger. As a matter of fact, however, Harris's method often possesses elements of uncertainty, because the septum may not be perfect and the urine from one side sometimes contaminates the urine from the other. Catheterization of the ureters is not so safe, is far more difficult, but gives more certain results.

Vesical hemorrhage, including hemorrhage from the prostate, may follow the relief of retention of urine, may be due to stone, inflammation, tumor, etc., or may arise from traumatisms, instrumental or otherwise. The color of the urine is usually bright red, but if long retained in the bladder it becomes black and often tarry. The reaction is alkaline. The clots, when floated out, are large and without definite shape. In micturition the urine is clear or only a little colored at the beginning, but becomes darker and darker as micturition ends, at which time the flow may consist of almost pure blood. In very small vesical hemorrhages the urine may be smoky. Crystals of triple phosphate indicate bladder disorder. The microscope shows colorless and swollen corpuscles and many polygonal cells. Symptoms of bladder mischief usually exist, but cystoscopic examination or exploratory suprapubic cystotomy may be required for the diagnosis.

Urethral Hemorrhage.—In urethral bleeding blood appears independently of micturition, or blood comes out first and is followed by clear urine. Urethral hemorrhage arises from acute urethritis, from an inflamed stricture, from the passage of an instrument, or from some other traumatism.

The source of urethral hemorrhage can be ascertained by the use of the endoscope.

Pain in Genito-urinary Diseases.—Pain as a symptom of genito-urinary disease may be found at some point distant from the seat of lesion. A stone in the bladder causes pain in the head of the penis just back of the meatus; stone in the kidney induces pain in the loin, the groin, the thigh, and the testicle; inflammation of the testicle causes pain in the line of the cord in the groin. In other cases of genito-urinary disease pain is felt at the seat of lesion, as in urethritis and prostatitis. Pain felt before micturition, and being relieved by the act, is found in cystitis and in retention of urine. Pain is felt during micturition in inflammation of the bladder, prostate, and urethra, and in the passage of gravel or stone. Pain which is acute at the end of micturition is noted in stone in the bladder, in inflammation of the neck of the bladder, and in inflammation of the prostate gland. The pain of stone in the bladder, it may be observed, is ameliorated by rest and is aggravated by exercise. The pain of acute prostatitis is intensified by defecation.

Frequency of Micturition.—Frequent micturition arises from irritation of the sensory nerves, from phimosis, contracted meatus, inflammations, very acid urine, calculi, urethral stricture, and hyperesthesia of the urethra. Frequency of micturition may be due to spinal irritability from concussion or from sexual excess, from contraction of the bladder rendering the viscus unable to hold much, from worry, anxiety, fear, or from excessive urinary secretion, as in diabetes or in the first stage of contracted kidney. Frequent micturition exists in obstruction by enlarged prostate and in atony of the bladder-walls. Hypersecretion of urine plus bladder intolerance is known as "nervousness," and is found in hysteria. Frequency of micturition increased

by *movement* is observed in stone and tumor of the bladder. Nocturnal frequency of micturition is present in cases of enlarged prostate and atony of the muscular walls of the bladder. Frequency of micturition with diminution of stream-caliber suggests a constriction of the urethral diameter; frequency of micturition with diminished force suggests a posterior stricture, enlarged prostate, or bladder atony. Slowness of micturition hints at enlarged prostate, atony, or urethral stricture.

Sir Henry Thompson's diagnostic questions are as follows:

"1. Have you any, and, if so, what, frequency in passing water? Is frequency more manifest during the night or the day? Is frequency more manifest during motion or rest? Does any other circumstance affect it?

"2. Is there pain on passing urine, and, if so, is it before, during, or after the act? What is its character—acute, smarting, dull, transitory, or continuous? What is its seat? Is it felt at other times, and is it produced or intensified by sudden movements?

"3. What is the character of the stream? Is it small or large; twisted or irregular; strong or weak; continuous, remitting, or intermitting? Does it come by the meatus, or partly or entirely through fistulæ?

"4. Is the character of the urine altered? What is its appearance, color, odor, reaction, and specific gravity? Is it clear or turbid, and, if turbid, is it so at the time of passing? Does it vary in quantity? Are the normal constituents increased or diminished? Does it contain abnormal elements, as albumin or sugar? What inorganic deposits are found? What organic materials are met with?

"5. Has the urine ever contained blood? If so, was the color brown or bright red; were the blood and urine thoroughly mixed; was the blood passed at the end or at the beginning of micturition, or did it come only with the last drops of urine; or was it passed independently of micturition?

"6. Inquire as to pain in the back, loins, and hips, permanent or transitory, and for the occurrence of severe paroxysms of pain in these regions."

The Determination of the Excretory Capacity of the Kidneys in Health and in Disease.—The Phloridzin Test.—This test is made with comparative ease and often aids the surgeon in determining whether he is justified in performing some operation of convenience. It enables him to estimate with a fair amount of accuracy the capacity for elimination possessed by the kidneys. The test depends on the fact that the healthy epithelium of the glomeruli and tubes, when stimulated to activity by phloridzin, forms sugar from that drug and thus produces temporary glycosuria. When the epithelium is diseased, little or no glycosuria occurs. The test is applied as follows: The dose is about 5 to 10 milligrams of phloridzin, according to the body-weight of the patient. It is administered hypodermatically, the bladder having been emptied beforehand. If the eliminating powers of the kidney are at a healthy level, sugar should appear in the urine within half an hour of the injection. If at the end of this time only a small amount of sugar can be detected, one may assume that the kidneys are affected; and if no sugar can be found, a serious renal disease may be assumed to exist.

The actual standard that is to be considered as the normal amount of sugar which should be eliminated after the administration of phloridzin is a matter of some uncertainty. It is usually estimated at 0.3 per cent., a less amount

of sugar than this being taken as an evidence of renal difficulty (Watson and Bailey, in "Report of Boston City Hospital for 1902"). The sugar is separated from the phloridzin in the epithelium of the glomeruli and tubules of the cortex of the kidney. The drug seems to be entirely harmless.

It is because phloridzin is acted upon by the kidney-epithelium that this test is better than the methylene-blue test. The latter does not really measure the excretory power of the kidney-epithelium: it merely shows to what degree the kidney is permeable in the mechanical sense. Personally, I should not be disposed to set aside older and more thorough methods of urinary analysis for the phloridzin test, although I believe that it has a range of distinct usefulness.

The Methylene-blue Test (The Method of Achard and Castaign).—When methylene-blue is injected hypodermatically it normally appears in the urine within half an hour and disappears in from thirty-six to forty-eight hours. If the blue color is not manifest in the urine for an hour or more, there is impairment of renal permeability. Accuracy in the test is not possible unless the amount of the methylene-blue actually passing into the urine in a given time is determined. The dose given hypodermatically is 0.05 gm. in 1 c.c. of sterile water. The test is unreliable and the blue color may appear in the urine in half an hour in some cases of marked kidney disease.

Cryoscopy (Korányi's Method).—Cryoscopy is the determination of the freezing-point of a liquid and the comparison of this with the freezing-point of distilled water. It is applied particularly to blood and urine. This method is complex and difficult of application, and requires a considerable amount of fluid. The freezing-point of a fluid depends upon the number of molecules it contains. The freezing-point goes hand in hand with molecular concentration—great concentration gives a low freezing-point, little concentration a high freezing-point. Cryoscopy of the blood and urine is used to determine the adequacy of renal activity. Normal blood freezes at about —0.56° or —0.57° C. Healthy urine freezes between —0.9° and —2° C. In renal inadequacy the freezing-point of the blood is lower than normal and the freezing-point of the urine is higher. It is held that surgical operation is contraindicated if there is such a degree of renal inactivity that the freezing-point of the blood is at or below —0.6° C. and if the freezing-point of the urine is at or above 1° C.

Diseases and Injuries of the Kidney and Ureter.

Tumors of the Kidney.—Tumors, innocent or malignant, may arise in the kidney. Among the innocent tumors are fibroma, lipoma, angioma, and adenoma. Hypernephroma of the kidney arises from fragments of adrenal tissue included in the kidney. The tissue of such a tumor is identical with the adrenal gland, and it contains fat and glycogen. The exact nature of such a tumor is unsettled. It is probably an adenoma, but some consider it to be a sarcoma and others a carcinoma. It grows rather rapidly, attains a large size, and is sometimes painful. A patient in the Blockley Hospital from whom I removed a hypernephroma complained of tenderness in the left side and occasional attacks like renal colic during which he passed bloody urine. The tumor could be easily palpated in the left loin. The kidney

was removed and resembled a huge kidney of nearly normal shape but nodular in outline. Dr. Coplin found it to be hypernephroma. A malignant tumor may be either sarcoma or carcinoma. Sarcoma is most common in the young, and may reach an enormous size (Fig. 684). A malignant tumor of the kidney produces hematuria, the urine often containing blood-casts of the ureter, kidney, and pelvis, and sometimes, though rarely, characteristic cells. Pain is often present in the loin and thigh, and there may be colic-like attacks when clots are passing through the ureter. Emaciation is rapid and pronounced. A tumor can usually be palpated. The only possible treatment for a malignant growth is early nephrectomy. In some few cases an inno-

Fig. 684.—Sarcoma of kidney with metastasis (Horwitz).

cent tumor can be removed by a partial nephrectomy. A malignant tumor requires a complete nephrectomy. In making a diagnosis of renal tumor use the cystoscope. If blood is coming from a ureter, note if it is from only one or from both. Blood from both would contraindicate nephrectomy. Before removing a kidney it is necessary to be sure that the patient is possessed of two kidneys. Note if urine flows from each ureter, or, if uncertain, catheterize the ureters.

Nephroptosis, Prolapse of the Kidney, or Mobile Kidney.—There are two forms of this condition: (1) *Movable kidney*, which is an organ freely moving back of the peritoneum, either within the cavity of its fibro-fatty capsule or entirely without its capsule (this condition is acquired); and

(2) *floating* or *wandering kidney*, an organ having a mesonephron and lying within the peritoneal cavity (this rare condition is always congenital). Keen states that there may be drawn a clear theoretical distinction between movable and floating kidney, but practically there is no rigid line of demarcation, as a movable kidney may have as large a range of movement as a floating kidney. The kidney is normally somewhat mobile, and nephroptosis is considered to exist only when the range of movement exceeds distinctly what is normal. Normally, on inspiration the kidney descends about half an inch. It is seldom that a normal kidney can be palpated in men, but in most women the right kidney can be palpated, and in some women the left organ can also be felt. Harris ("Jour. Amer. Med. Assoc.," June 1, 1901) describes three degrees of movable kidney. In cases of the first degree, one-half of the organ can be distinctly grasped and the kidney can be made to recede. In cases of the second degree both hands can be brought together above the kidney. In cases of the third degree the kidney has descended as low as the pelvic brim or has moved to or beyond the umbilicus. The organ may drop below the brim of the pelvis, may cross the vertebral column, or may reach the anterior abdominal wall. When a movable kidney becomes fixed in an abnormal situation, the organ is spoken of as *dislocated*.

Women suffer from movable kidney more often than do men. Küster estimates that 4.41 per cent. of women examined in general surgical practice have movable kidney. Edebohls finds it in 20 per cent., and Harris in 56 per cent., of cases in gynecological practice. In about one-half of the cases it gives rise to little or no trouble. A movable kidney is found in the great majority of cases upon the right side. In many cases it is bilateral, the right kidney being usually the most mobile. Splanchnoptosis may be associated with acquired nephroptosis. Floating kidney is always congenital. The condition is occasionally, but rarely, found in children, though congenital cases occasionally occur. In a congenital case there is not splanchnoptosis. Tuffier has reported 3 cases in children six, nine, and ten years of age respectively, and J. Cromby reported 18 cases of floating kidney in children, the youngest patient being three months of age (quoted by Harris in "Jour. Amer. Med. Assoc.," June 1, 1901). Among the assigned causes of the movable condition are to be named traumatism; strains; abdominal-wall laxity from pregnancy, removal of a tumor, or tapping for ascites; absorption of peritoneal fat from wasting disease (Edebohls); tight lacing; uterine displacements; and enteroptosis leading to traction on the transverse mesocolon. The condition is certainly often associated with ptosis of the other abdominal viscera (enteroptosis, gastroptosis, etc.).

Traumatism is rarely the immediate and essential cause of a true movable kidney. In some cases people assert that pain began immediately after a blow, an attack of coughing, violent vomiting, lifting, straining at stool or in parturition, or a fall. In such cases the kidney may have been mobile before the accident. Again, pain is not proof of the inauguration of movability. It is probable, however, that traumatism may loosen the kidney and that mobility may subsequently develop. Gutterbock says that a kidney in normal relations cannot be rendered mobile by a simple fall or a trivial force. Loosening can be induced only by rupturing surrounding tissues; and if this happens, symptoms of a distinct nature will indicate the seat of

injury. Harris makes out a strong case for the view that the condition is due to the relation existing between the location of the kidney and the body form. He divides the body into three zones. The upper zone contains the lungs and heart. The middle contains the liver, stomach, spleen, pancreas, and the greater part of each kidney. The lower contains the intestinal canal and the lesser part of each kidney. When there is a naturally small or a diminished capacity of the middle zone, the kidney is displaced downward. The right kidney is pressed upon by the heavy liver, which drives it down; the left kidney is pressed upon by the comparatively small spleen. Hence movable kidney is more common on the right side than on the left. The upper pole of the kidney is first pushed forward and then the entire organ descends (M. L. Harris, in "Jour. Amer. Med. Assoc.," June 1, 1901). Harris maintains that the amount of mobility depends upon the degree of contraction of the middle zone and upon internal traumatisms (lifting, straining, coughing, etc.).

Symptoms of Both Forms.—There may be no discomfort whatever, or the patient may be a confirmed invalid. The usual symptoms are epigastric pain (just to the left of the middle line), which disappears when the kidney is replaced, dragging pain in the loin, and paroxysms like nephritic colic. Sudden attacks of violent pain in the kidney or stomach may occur—attacks which are accompanied by nausea, vomiting, great weakness or collapse, vertigo, chills, and subsequently elevated temperature (*Dietl's crises*). Dietl's crises are due to kinking or twisting of the ureter or renal vessels or to inflammation of the kidney. They may be caused by physical exertion or indiscretion in diet and may be followed by hydronephrosis or strangulation of the renal vessels. A few years ago I operated upon a man suffering from a violent and prolonged crisis and found a twist of the vessels and ureter. In a Dietl's crisis there is congestion or strangulation or both (C. P. Noble). An incomplete or temporary twist of the renal pedicle may induce simply pain in the abdomen and loin, hematuria, albuminuria, and cylindruria.

The question as to whether or not abdominal pain is due to movable kidney is sometimes in doubt. The localization of the pain may lead us to suspect appendicitis. Some surgeons think that catarrhal appendicitis is often associated with movable kidney, but I do not think the association is common. "Dr. Kelly has shown us how to solve this doubtful question between appendicular pain and the pain of movable kidney. He catheterizes each ureter separately, and introduces into each catheter as much as the renal pelvis will hold without causing pain. He then measures this fluid from each side, and determines whether it is in excess of an estimated average. If it is in excess, he is sure that dilatation has begun. He then injects the kidney again, with the deliberate purpose of producing pain; and if the patient recognizes this pain due to the distention as of the same character and in the same position as that which he has previously felt, Dr. Kelly assumes that the pain has been due to the kidney, and not to the appendix, and recommends an operation to fix the kidney" (the author, in "New York Med. Jour.," August 4, 1906). Usually in a case of movable kidney there is a sense of a moving body in the abdomen, and the patient has aggravated indigestion, often accompanied by vomiting. Constipation is the rule, and violent attacks of cardiac palpitation are common. Most subjects of

this kidney mobility are extremely nervous—many of them hysterical or hypochondriacal. Persistent vasomotor paresis causes cold hands and feet and often albuminuria. Temporary jaundice is not uncommon. There is frequently irritability of the bladder. Vertigo and insomnia are present in many cases. The patient cannot sleep when lying on the sound side (Goelet). In women the sexual organs are almost invariably deranged, and menstruation aggravates the pain and discomfort. All the symptoms are intensified by exertion and are modified by rest. The urine is normal, except after violent exercise, when it may contain blood. Splanchnoptosis may also exist, and if it does, the pulsations of the abdominal aorta are strongly noticable because that structure is bared by gastroptosis. The proof of the existence of movable kidney is the finding of a tumor, movable on respiration, change of position, and palpation, shaped like that organ, pressure upon which occasions no sensation or causes pain or a sickening feeling. A "lumbar recess" (Morris) may sometimes be found, and percussion over the loin gives resonance. In some cases a movable kidney can be readily detected when the patient stands up, but is difficult to find when he is recumbent. Franks's method of examination is very satisfactory. The patient is placed recumbent. If dealing with a right kidney, the surgeon stands to the right side and pushes four fingers of his left hand in the loin below the twelfth rib, and rests the thumb lightly in front just below the ribs. The patient takes a full breath and holds it a moment, and just before he empties his lungs the surgeon presses his thumb up deeply below the ribs. During expiration the thumb follows the liver, and the fingers press toward the front. If with the right hand the kidney can be felt entirely below the left hand, the case is one of movable kidney. If such a condition is detected, press hard with the right hand, and gradually loosen the grasp of the left hand, and the kidney will slip between the fingers and ascend. A normally mobile kidney descends so that its lower end can be felt, but it moves back during expiration.* Goelet uses Kendal Franks's method of palpation, but has the patient stand, with the weight resting on the leg of the sound side and with the leg of the impaired side slightly flexed and resting on the toes. The body leans a little forward. A movable kidney must not be mistaken for a distended gall-bladder, a tumor of the mesentery, stomach, or omentum, a phantom tumor, an ovarian tumor, or a cancer of the pancreas. A distended gall-bladder can be pushed upward, but not backward, and not downward unless the liver is movable; it is extremely tender, and cannot be pushed out of reach. A kidney can be pushed upward and backward—in fact, in all directions. An enlarged gall-bladder can always be palpated. A movable kidney which is not enlarged can be felt at times and not at others (Henry Morris). A movable kidney may pass between the examiner's fingers, and if pushed into the loin, it tends to remain; but if a distended gall-bladder is pushed into the loin, it springs out as soon as pressure is relaxed (Henry Morris). It is important to remember that in about one-half of the cases of movable right kidney the left kidney is also movable, but to a less degree. Appendicitis is thought by some to be more frequent in individuals with movable kidney than in those who do not suffer from it. Sometimes a movable kidney endangers life, rupture of the kidney, twisting or rupture of the ureter, or strangulation of the renal

* Brit. Med. Jour., Oct. 12, 1895.

vessels occurring, the ultimate cause of death being albuminuria, uremia, or hydronephrosis.

Treatment.—Mobile kidney is treated as follows: If the kidney is but slightly mobile and there are no local symptoms, the treatment should be non-operative. (1) *The rest-treatment of S. Weir Mitchell* may be tried; it often markedly mitigates the symptoms, but does not seem to cure. (2) *Mechanical support* should always be tried. The most satisfactory mode of applying it is by the corset recommended by Gallant ("Amer. Jour. Obstet.," July, 1901). This corset is long and straight in front, and when applied, fits firmly over the hips and lower abdomen, less firmly at the waist, and least firmly above.

Gallant directs that the patient lie down, the head being on a pillow and the knees drawn up. While in this attitude the corset is put on and it is laced from below up. If the attempt to apply the corset develops tenderness, keep the patient at rest in bed until it can be applied without pain. In some cases conservative treatment is not indicated; in others it fails.

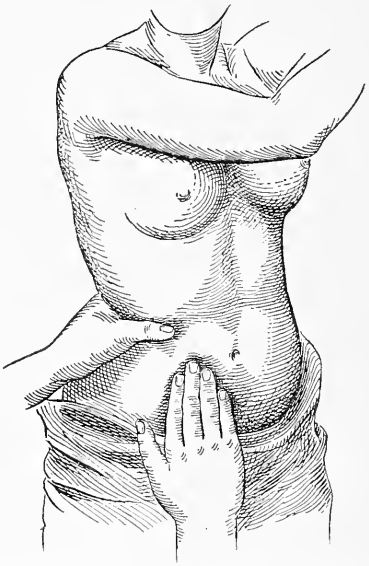


Fig. 685.—A. H. Goelet's method of palpation for the detection of a prolapsed kidney.

In every case of very movable kidney and in some cases in which movability is not great operation is indicated.

"In a case in which the kidney exhibits trivial movability, but in which the range of mobility is found to be gradually and certainly increasing, or in any case of kidney movability in which there are distinct local symptoms, operation is indicated. The distinct local symptoms mean the beginning of actual harm to the kidney, and the progressive increase of movability means the ultimate attainment of a wide range of movement. A kidney which is widely movable may at any time twist upon the ureter and the renal vessels; and it is certain to suffer from partial or slight twists, probably many times repeated in the twenty-four hours, even if a severe twist does not occur. A deduction from the foregoing statements is that a patient suffering with nephroptosis, even when the mobility is slight, should be examined at regular intervals, to note whether the area of movement is extending, or whether local symptoms have arisen. Three local symptoms that should be regarded as indications for operation are severe pain in the renal region, distinct tenderness of the kidney, and enlargement of the kidney" (the author, in "New York Med. Jour.," August 4, 1906).

The operation chosen will be either nephropexy or nephrectomy. (1) *Nephropexy* is the operation employed in most instances (page 1120). It is the author's experience that if the patient has had marked nervous symp-

toms for a long time, nephropexy will rarely cause them to pass away permanently, even though the kidney remains firmly anchored. (2) *Nephrectomy* is necessary only in very rare cases; it may be done for dislocated kidney, when grave kidney disease exists, or when nephropexy has failed in a case of great severity.

In many cases of this trouble no operation should be performed, the use of Gallant's corset securing, perhaps, decided or complete relief. I do not operate if the kidney is only slightly movable and if there are no local symptoms or if there are merely the general symptoms of hysteria. If the mobility is slight and the hysterical and neurotic condition is pronounced, anchoring the kidney will not cure the nervous condition. In these nervous cases, associated with prolapse of the kidney, there is usually, also, prolapse of the other abdominal viscera; and both kidneys are, as a rule, movable, the right, however, being decidedly more movable than the left.

If there is but slight mobility of the kidney, but the range of movement is, week by week and month by month, increasing, or if we find a case of movable kidney in which there are distinct local symptoms, an operation should be performed. The existence of definite local symptoms means beginning harm to the kidney; and if we find the area of movement gradually increasing, we know that eventually it will become extensive. Any widely movable kidney may twist the ureter and the renal vessels, producing serious trouble or even disaster, and consequently should be fixed by operation. Even if a severe twist does not take place, it is bound to suffer from partial or slight twists. Such kidneys will eventually become hydronephrotic. The meaning of the term slight mobility is indicated on a previous page (p. 1102).

One is not unusually in doubt in cases of movable kidney whether a pain indicates local trouble with the kidney or catarrhal appendicitis, because the pain may be located in the appendix region. Kelly, of Johns Hopkins Hospital, has shown how to solve this problem (p. 1103).

There are many operations for movable kidney. In all of them the kidney is exposed in the loin. Some make a vertical and some an oblique incision. Edebohls makes a vertical incision, forces the kidney out of the wound, incises the fibrous capsule longitudinally, turns a cuff down on each side, and applies sutures. These sutures traverse the kidney-substance and the fold of capsule on each side. The upper suture catches the periosteum of the last rib; the other sutures catch the lumbar fascia. Drainage is not required, and the suture material employed is kangaroo-tendon or chromicized catgut.

Many surgeons simply pass sutures through the uncut capsule and the kidney-substance and thus fasten the kidney to the lumbar fascia. Others split the capsule and pass sutures through the edge of the capsule and the wound-edges, but not through the kidney-substance.

To promise success, an operation ought to restore the kidney nearly to its normal position and fix it permanently in place. It is undesirable to inflict damage on the kidney itself, and I do not believe in any operation that passes sutures through the kidney-substance. In cases in which decapsulation is performed, the kidney will grow fast without any special method of suturing.

Most of the operations suggested do not place the kidney sufficiently high up to get it into a fair position. Kelly's operation gets it higher than most

of them, and Goelet's operation gets it well into place. In many of the suture operations the sutures are placed in the convex surface of the kidney or the kidney capsule, and on fixing the kidney by tying the sutures there is a permanent quarter twist of the ureter—a condition that may be responsible for great pain. This may be obviated entirely by the ingenious method of Goelet ("Annals of Surgery," Dec., 1903). I believe, however, that the suture operations which do lift the kidney well up toward its proper place and in which the sutures are applied on the posterior surface and not the convexity, tilt the upper pole forward into a permanent and perhaps disastrous position. Such operations lift the kidney from below its mid-line and thus fix the lower half of the organ, but leave the upper half unfixed. I believe, too, that in many cases in which kidneys have been sutured they get loose again and that the best operation, after all, is that by the use of slings of iodoform gauze (page 1120).

Injuries of the Kidney.—Laceration or **rupture** is caused by falls and by blows upon the back or the belly.

Symptoms.—In some cases the parenchymatous structure is torn, but the capsule is not torn, and in consequence urine and blood are not extravasated into the perineal connective tissue or into the peritoneal cavity. In other cases the parenchyma and capsule are both torn and urine and blood are extravasated. The laceration may be trivial, may be considerable, or may tear the kidney apart. The symptoms depend on the gravity of the injury. A slight tear without involvement of the capsule may produce practically no symptoms at all. A more severe injury produces shock, and, if profuse bleeding occurs, the general symptoms of hemorrhage. In intraperitoneal rupture there is profuse and usually fatal hemorrhage. In laceration of the kidney there are severe pain in the loin, which shoots into the testicle, and lumbar tenderness. If there is considerable perirenal bleeding, the loin will be full, and dull on percussion, and if the hemorrhage is large, a palpable mass will form after a time and after some days the skin will become discolored. There is frequent and painful micturition and sometimes suppression of urine. Hematuria occurs in renal laceration unless the rupture was intraperitoneal or the ureter was torn, in which case there are evidences of profuse internal hemorrhage, abdominal rigidity, etc. (Daniel N. Eisendrath, "Jour. Amer. Med. Assoc.," Oct. 25, 1902). It is important to remember that hematuria can arise from simple renal contusion, and that kidney damage does not of necessity cause bloody urine. If there is hematuria, the use of the cystoscope or catheterization of the ureters, or the employment of Harris's segregator, will demonstrate from which kidney the blood comes. A kidney-laceration may be followed by secondary hemorrhage, perirenal suppuration, hydronephrosis, or pyonephrosis, and may cause kidney displacement.

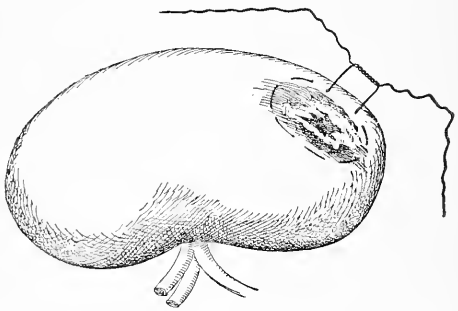


Fig. 686.—"Purse-string suture" applied to a perforation (after Schachner).

Treatment.—In an intraperitoneal rupture laparotomy should be performed because of abdominal hemorrhage. As a rule, nephrectomy is necessary, but it may be possible to arrest hemorrhage by packing. If the shock is pronounced and if there is increasing fulness in the loin, whether hematuria exists or not, or if blood comes profusely from the ureter, whether or not there is much shock or lumbar fulness, make an exploratory lumbar incision and stop the bleeding by packing or by a purse-string suture (Figs. 686, 687), or, if necessary, perform partial, or even complete, nephrectomy. Ordinarily, when there is not great shock, increasing lumbar swelling, or severe hematuria, treat by rest in bed and by feeding with liquid food or by nutritive enemata to prevent vomiting. Opium, tannic acid, or gallic acid may be used. Apply ice-bags to the loin and the side of the abdomen, and after bleeding ceases strap the loin and apply a binder. If large blood-clots in the bladder cause pain or retention of urine, introduce a catheter and inject the bladder with boric acid, or use the tube and evacuator of a Bigelow apparatus. If this procedure fails, open the bladder by a suprapubic incision and drain.

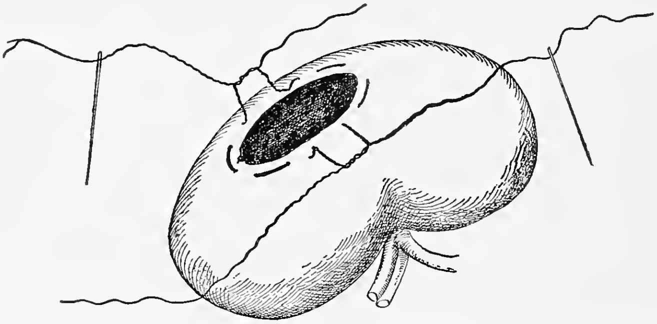


Fig. 687.—Showing the application of a double "purse-string" suture for the arrest of hemorrhage in large wound (after Schachner).

Results of Operation.—Up to 1894 there had never been a case of intraperitoneal rupture operated upon; since then 6 have been operated upon and all recovered (Daniel N. Eisendrath, "Jour. Amer. Med. Assoc.," Oct. 25, 1902). Küster collected 47 cases of nephrectomy, and 83 per cent. recovered. Keen estimates the mortality of primary nephrectomy for rupture at 20 per cent., and of secondary nephrectomy at 38.5 per cent. Without operation intraperitoneal rupture is inevitably fatal. Six recorded cases operated upon recovered. Of extraperitoneal ruptures, 70 per cent. recover without operation (Eisendrath). Francis S. Watson ("Boston Med. and Surg. Jour.," July 16, 1903) has collected 660 cases of subparietal injury of the kidney. The following statistics are of interest: Treated expectantly: 273 cases with 81 deaths, a mortality of 29.6 per cent. Treated by operations other than nephrectomy: 99 cases with 7 deaths, a mortality of 7.7 per cent. Treated by nephrectomy: 115 cases with 25 deaths, a mortality of 21.7 per cent.

Perforating wounds of the kidney, if purely posterior, do not involve the peritoneum; if anterior, they do. The *symptoms* are escape of blood

and urine by the wound; hematuria is usual, but not invariable; pain as in rupture; the patient may be unable to micturate; and nausea, vomiting, and constitutional signs of hemorrhage exist. Traumatic peritonitis, perinephric abscess, or general sepsis may ensue. Confirm the diagnosis by exploration with the finger. Extraperitoneal injuries give a good, and intraperitoneal a bad, prognosis.

Treatment.—If the wound of the kidney is extraperitoneal, enlarge the lumbar wound to permit of drainage, and arrest hemorrhage by packing and hot water or by a purse-string suture (Figs. 686, 687). Asepticize the wound, insert a drainage-tube down to the kidney, dress often with bichlorid gauze, keep the patient in bed on a low diet, and give gallic acid and opium. In some cases nephrectomy, partial or complete, will be required. In intraperitoneal wounds perform an abdominal section and, as a rule, remove the damaged organ (see Nephrectomy).

Wounds of the Ureters.—Rupture from external violence is an extremely rare accident. There are 3 undoubted cases on record (Daniel N. Eisendrath, "Jour. Amer. Med. Assoc.," Oct. 25, 1902). A rupture or wound from accidental violence is almost invariably associated with other serious injuries. The ureter may be wounded by the surgeon accidentally during the performance of an abdominal operation, or it may be wounded intentionally, as in Morris's cases, in which a malignant growth was incorporated with the ureter. There is particular danger of injuring the ureter in operations upon intraligamentary growths, because the ureter is displaced and often resembles an adhesion. The rule of surgery is that when working about the ureter the surgeon neither clamps nor cuts any structure without a careful preliminary examination. Rupture causes severe shock and extravasation of urine around the kidney or into the peritoneal cavity. In extraperitoneal rupture a palpable mass forms in the loin. When the ureter is divided in an operation, a flow of urine is seen.

Treatment.—The upper three-fourths of the ureter can be reached by an extraperitoneal incision, which is a prolongation of the incision for lumbar nephrectomy, running from the twelfth rib downward, and forward to one inch anterior to the anterior superior spine of the ilium, and then parallel to Poupart's ligament until a point is reached above its middle (Fenger). Israel's incision begins at the anterior edge of the erector spinæ mass, one finger's length below the twelfth rib, is taken forward parallel with the rib until it reaches the line of the rib's tip, and is then carried toward the middle of Poupart's ligament until the line for ligation of the common iliac artery is reached, and is then taken toward the middle line as far as the outer border of the rectus muscle. The lower one-fourth of the ureter can be reached by abdominal section or by sacral resection (Cabot). If it seems probable that the ureter is wounded or ruptured, explore, and if this is found to be the case, endeavor to restore the continuity of the tube (Fenger). A longitudinal cut can be sutured with fine catgut. If the ureter is cut across near the bladder, implant the proximal end into the bladder and ligate the distal end (Van Hook, Penrose, Kelly). If it is cut above the bladder portion, perform lateral implantation by Van Hook's method (page 1122).

A longitudinal wound of the ureter inflicted during an abdominal operation should be sutured, but if the duct cannot be readily reached, simply

make a posterior incision and drain with rubber tissue, as the longitudinal wound will heal by granulation if no sutures are inserted (Van Hook). In a case of transverse division perform uretero-ureterostomy or vesical implantation; or, if neither of these methods is feasible, make a urinary fistula or perform nephrectomy.

Renal Calculus.—A stone in the kidney is formed by the precipitation of urinary salts into the renal epithelial cells and the gluing together of these salts and cells by material from mucus or blood-clot, this mass serving as a nucleus on which accretion takes place. Most calculi escape when small, as *gravel*. The **cause** is a highly acid urine, which induces catarrh of the renal tubes. Such high concentration of urine is favored by a sedentary life, by the ingestion of much alcohol or nitrogenous food, by constipation, by an inactive skin, and by a torpid liver. The children of poverty are liable to calculi because of the use of unsuitable foods and the formation of great amounts of nitrogenous waste. Males suffer more often than do females; certain locations favor the development of the malady, and a family tendency sometimes exists.

Symptoms.—The symptoms of stone in the kidney may not appear for years, but generally they are manifested early. The patient usually complains of pain in the loin, and sometimes of pain in the iliac region. Deep percussion over the kidney causes pain in the loin, even when pressure is painless (Jordan Lloyd's symptom). Pain is aggravated by exercise. The urine is often somewhat albuminous, and may from time to time contain blood. Frequency of micturition is noted during the day, but not at night. The urine may be purulent. Nephritic colic is due to the washing of a calculus into the orifice of the ureter, which it blocks, tears, or distends. The pain is either sudden or gradual in onset, is fearful in intensity, and runs from the lumbar region down the corresponding thigh and spermatic cord (the testicle being retracted) and into the abdomen and back. There are nausea, vomiting, collapse, sometimes unconsciousness or convulsions. Frequent attempts at urination are productive of pain, but of little urine. The urine is usually, but not always, smoky from blood. After a time the pain vanishes, the stone having passed into the bladder or having fallen back into the pelvis of the kidney. A calculus retained in the kidney eventually excites pyelitis, pus appears in the urine, and soreness or pain in the loin exists. Kelly says: Even if pus is found we are not always sure from which kidney it came. Pain or swelling may point to one side, but we are not sure that the outer organ is not also affected. If able to pass the renal catheter into one ureter, attach a syringe, and by making suction draw out any pus which may be present. In renal calculi cases this fluid is apt to contain fragments of uric acid. By using a renal bougie coated with dental wax it may be possible to make scratches on the instrument when it comes in contact with a concretion.* Slight attacks of colic occur from the passage of small stones or of plugs of mucus. When a stone is impacted in the pelvis the point of greatest tenderness on pressure is below the last rib, by the edge of the erector spinæ muscle. In most cases a stone in the kidney or ureter can be skiagraphed. Nephrolithiasis may cause death by exhaustion, by sepsis, by rupture of a hydronephrosis, or by amyloid degeneration.

*Howard Kelly, in Med. News, Nov. 30, 1895.

Treatment.—For the gravel of the uric-acid diathesis use alkalies, especially the liquor potassii citratis, and reduce the amount of nitrogen in the diet to a minimum, at the same time washing out the organs by copious draughts of Poland water or Londonderry lithia. Piperazin, in doses of gr. v to gr. viij three times a day, is highly commended. Exercise is to be insisted on. When gravel is phosphatic, order strychnin, the mineral acids, and rest at the seaside. When oxalate of lime is found, restrict the diet, use the mineral acids, recommend travel or rest amid new surroundings, and give an occasional course of sodii phosphas, ʒss three times a day, drunk in Buffalo lithia water. Nephritic colic is relieved by hypodermatic injection of morphin and atropin, the hot bath, diluent drinks, or the inhalation of ether. After the attack wash out the bladder with an evacuator to remove any stone which may have reached there. If a stone impacts in the ureter, perform the operation of *ureterolithotomy*. The diagnosis of this impaction is in many cases aided by the *x*-rays, but is sometimes possible only after exploratory laparotomy. If the symptoms point to stone in the kidney, medical treatment having been used without avail, always take a skiagraph. If this shows a stone, and if there are no evidences of organic disease of the kidney, operate. If in doubt in spite of the skiagraph, make an exploratory lumbar incision; feel the surface of the kidney with the finger, sound the inside of the organ with a needle, and if a stone is detected, incise the kidney and remove the stone. Keen is of the opinion that operation should not be performed if the urea is below 1 per cent. If, after nephrolithotomy, suppression of urine occurs, cut into the other kidney, as in half of all cases a stone will be found lodged there.

Calculus in the Ureter.—A ureteral calculus comes from the kidney, sometimes dropping, but more often being forced, into the tube. A stone may be arrested just below the renal pelvis, at the pelvic brim, or near the opening into the bladder.

Symptoms.—Attacks of violent pain of the nature of renal colic, and not unusually a rigor with the attack and fever after it. Such an attack may be followed by hematuria. Tenderness can be developed at the point of impaction, the point of greatest tenderness being in the loin below the level of the kidney or in the iliac region (Perkins). If a stone partly obstructs the ureter, the urine is pale, of low specific gravity, and free from albumin. Impaction near the bladder causes symptoms similar to stone in the bladder (Jordan Lloyd). Impaction near the kidney is accompanied by hematuria and pyuria. In stone in the ureter pain is not developed by pressure in the loin at the level of the kidney. Complete obstruction of the ureter causes hydronephrosis or pyonephrosis. In some cases a stone acts as a ball-valve, plugs the ureter for a time, during which a lumbar mass develops, and then allows the urine to flow. A copious flow of urine is accompanied by disappearance of the lumbar mass.

In a woman, a stone lodged in front of the broad ligament may be felt by a finger in the vagina. Back of this region and up to the pelvic brim a stone may be felt by a finger in the rectum. A cystoscopic examination, in unusual cases, may show a portion of stone projecting from a ureter (Kelly). If a ureteral catheter tipped with wax is introduced, a calculus will make distinct scratches upon it (Kelly). The *x*-rays are very valuable in diagnosis.

Treatment.—During a painful paroxysm give morphin and use hot

packs. The attack may terminate and not return, because the calculus passes. If such an attack does pass away, the urine should be examined after every act of micturition to see if the stone is voided from the bladder. After a day or two, if the stone does not appear, the Bigelow evacuating apparatus must be used, otherwise the retained fragment will enlarge and give trouble subsequently. If the stone is impacted, operate. The extraperitoneal operation is to be chosen. Even when the stone is impacted below the pelvic brim, it is better to do the extraperitoneal operation, stripping the peritoneum and reaching the ureter from behind. (See Ureterolithotomy.)

Abscess of the kidney is caused by traumatism, by calculus, by stricture of the urethra, by disease of the bladder, by the union of miliary abscesses, or by pyemia.

The **symptoms** are pus in the urine (this is usual, but not invariable), hematuria in traumatic cases, and pain running into the groin. The urine in most cases is alkaline. Constitutional symptoms of suppuration exist, the fever being far higher than that generally met with in renal tuberculosis. The bladder should be examined with a cystoscope to determine that the turbid urine flows from the ureter and to identify the diseased side. It is well, if possible, to catheterize the ureters.

The **treatment** in the early stage is rest, morphin, purgation, anodynes, an ice-bag to the loin, followed in forty-eight hours by hot fomentations. When the diagnosis is clear, incise the loin, open and stitch the kidney to the abdominal wall, or, if the organ be badly damaged, remove it.

Pyelitis and **pyelonephritis,** which usually affect only one gland, are caused by urethral stricture, by stopping of the ureter by blood-clot, by vesical paralysis, by stone in the bladder or in the kidney, and by enlargement of the prostate gland.

Symptoms.—A patient who has, or who has had, retention of urine develops high fever, often preceded by a chill, and headache, stupor, and dry tongue are noted. Unlike acute Bright's disease, there is neither edema nor dry skin, convulsions do not occur, and the urine is plentiful and contains pus and but rarely blood. The **prognosis** is very bad.

The **treatment** is to remove the obstruction if possible. If the urine be acid, give liquor potassii citratis; if alkaline, give benzoic acid. Gallic acid, eucalyptol, and small doses of copaiba or cubebs are recommended. Venice turpentine, camphor, and opium may be given in pill form. Quinin is used to stimulate the patient. The bladder is to be washed out every day with boric-acid solution (gr. iij to ℥j of water). Cups, dry or moist, and hot sand-bags or bran-bags are to be applied to the loin. Alcohol may be sparingly administered. Urotropin is a useful drug.

Perinephritis is an inflammation of the perinephric fatty tissue produced by cold, febrile disease, slight traumatism, or the spread of inflammation from another part.

The **symptoms** of this condition are rigidity of the spine, the inclination being toward the affected side, flexion of the thigh, pain in the loin and iliac region, and often pain in the knee. The symptoms resemble those of hip-joint disease in the second stage. Suppuration may or may not take place.

The **treatment** is wet cups to the loin, ice-bags to the loin, rest, purga-

tion by salines, morphin for pain, and, after the acute stage, potassium iodid internally and ichthyol locally.

Perinephric Abscesses.—An abscess in the perinephric fat is known as a perinephric or perirenal abscess. *Primary abscess* is caused by chills, acute febrile disturbances, or by pus flowing from some other part, as the spine. Slight traumatisms, by producing hemorrhage, make the perinephric region a point of least resistance and lead to abscess. The causative injury may be produced by digging, stamping, coughing, falling, carrying a burden, lifting a weight, riding on a horse or on a jolting wagon. *Consecutive abscess* is secondary to kidney inflammation, suppuration, calculus, tuberculosis, or cyst. In the consecutive form the symptoms may be masked by the malady to which perinephric abscess is secondary. As a rule, in perinephric abscess there are found the constitutional symptoms of suppuration. The local symptoms are a deep aching and paroxysmal pain in the loin, intensified by lumbar pressure. There may be pain in the iliac region and pain in the knee. Edema of the corresponding foot and lameness are not unusual. The thigh is often drawn up. The spine is rigid and inclined toward the diseased side. Edema of the skin is usual, but fluctuation is not. The exploratory incision will settle a doubtful diagnosis.

The **treatment** is to lay open the abscess, wash it out, and drain.

Stricture of the Ureter. —This is usually at or near the termination of the ureter. It is due to gonococcic inflammation, pyogenic inflammation, or tuberculosis. The symptoms, as Howard Kelly says, are at first those of a vesical or renal inflammation. The diagnosis is made by the ureteral catheter. We may be unable to introduce it, we may introduce it with difficulty and find that the pelvis of the kidney is distended and that the urine obtained is slightly acid or even alkaline, much lower in urea than the urine from the other kidney, and perhaps contains pus. Stricture of the ureter causes hydronephrosis or pyonephrosis.

Treatment.—Dilatation with bougies, resection of the diseased portion and anastomosis, resection of the diseased portion and implantation of the sound end into the bladder, or division of the stricture and suture. In tuberculosis the diseased kidney and ureter may be removed.

Hydronephrosis is a condition of the kidney resulting from an impediment to the outflow of urine by obstruction in the ureter, the bladder, or the urethra, the calyces of the kidney becoming overdistended with urine and the glandular tissue being absorbed by pressure. It has been asserted by Albarran that secretion of urine ceases in a kidney whose ureter is blocked, distention being due purely to congestion. Hydronephrosis may be congenital, due usually to twisting of the ureter or to valve-formation obstructing the ureter at its point of junction with the pelvis of the kidney, the valve being produced because the ureter passes into the kidney pelvis at an unnatural angle. Occasionally imperforate meatus produces hydronephrosis of both kidneys. The **causes** of the acquired form are the pressure of pelvic growths or pregnancy, inflammation or tumor of the bladder, stone in the bladder, kidney, or ureter, twisting or kinking of the ureter of a movable kidney, enlargement of the prostate gland, and stricture of the urethra. Acquired hydronephrosis may involve both kidneys, all of one kidney, or only a part of a single gland.

Symptoms.—Hydronephrosis is most frequent in females. When a lumbar tumor is absent, there may be no symptoms, or there may be pain in the back and abdomen, frequent micturition, a persistent or intermittent diminution in urine, or even occasional anuria. A tumor may be found in the loin, which growth is dull on percussion and may come and go, a large urinary flow occasionally occurring when it disappears. Hydronephrosis may last a long while if only one kidney be involved, but death is not far distant if both glands suffer. Death occurs from uremia, from pressure on adjacent organs, or from rupture into the peritoneal cavity. The diagnosis is aided by the use of the cystoscope and by catheterizing the ureters.

Treatment by aspiration may cure, but the operation may have to be done repeatedly. Tapping on the left side is performed just below the last intercostal space; on the right side the tap is made midway between the last rib and the crest of the ilium. Some few cases have been cured by catheterizing the ureter (Pawlik). The proper operation in most cases is nephrotomy, stitching the edges of the cut kidney to the surface. After the kidney has been opened, explore the ureter by means of a uterine sound or an elastic bougie. A healthy ureter will permit the passage of an instrument of the size of from No. 9 to No. 12 of the French scale (Fenger). If the opening of the ureter into the pelvis cannot be found, open the pelvis or open the ureter. A valve should be slit longitudinally and sutured vertically (Fenger). If a permanent suppurating fistula ensues or if the organ is found extensively damaged, nephrectomy is to be performed, provided the other kidney is in reasonably good condition.

Pyonephrosis or **surgical kidney** is a condition in which the pelvis and the calyces of the kidney are distended with pus or with pus and urine. The whole kidney may be destroyed. This condition has the same causes as has hydronephrosis, for it is in reality usually an infected hydronephrosis. In some cases the inaugural malady is pyelitis, which causes blocking of a ureter. Watson, of Boston, has reported two cases associated with obliteration of the ureter by a mass of fibrous tissue (stricture of the ureter).

Symptoms.—At first the symptoms are those due to the obstructing cause, plus pyelitis. Pus may appear in the urine in incomplete obstruction, or it may intermittently come and go. Constitutional symptoms of suppuration are soon manifest. A tumor may appear in the loin, like the tumor of hydronephrosis. If only one kidney is involved, and if the disease is due to blocking of a ureter, recovery is to be expected. The diagnosis is rendered more certain by the use of the cystoscope and by catheterizing the ureters.

The **treatment** in the early stages comprises removal, if possible, of the cause of obstruction, and the employment of measures directed to the cure of the pyelitis. If obstruction is not complete, palliative measures may be employed for the tumor. If fever is continued; if there is great visceral derangement; if pain is severe and constant; and if the tumor continually grows, perform a nephrotomy, stitching the organ to the surface if possible, or removing it if it is hopelessly disorganized and the other kidney is in a good or a fairly good condition.

Chronic Tuberculosis of the Kidney.—This condition may begin in one kidney, no other area of infection existing in the body. In such cases the bacteria were deposited from the blood. Even when the bacteria are

deposited from the blood there is, in most cases, a causal focus of tuberculosis somewhere in the body. The other kidney is usually involved subsequently, the process in the first kidney affecting the bladder and secondarily the other kidney. The important point is that tuberculosis of the kidney arising in this manner is at first a unilateral disease.

Tuberculosis of the kidney is seldom a primary disease and usually arises secondarily to tuberculosis of the prostate, bladder, or epididymis. In such a condition the kidney disease is bilateral. Renal tuberculosis is particularly common in the third and fourth decades of life, and is more frequent in males than in females.

Symptoms.—Renal tuberculosis of arterial origin may exhibit no symptoms until the disease is far advanced. Renal tuberculosis secondary to disease of the bladder or prostate always presents symptoms.* A very common symptom of renal tuberculosis is the sudden onset of polyuria and frequent micturition. The patient is annoyed day and night, and in some cases micturition is distinctly painful. Paroxysms of renal pain are not unusual. The urine is acid, and may contain pus or blood. Tubercle bacilli may be found in the urine or in the sediment, but they may be absent. Repeated examination should be made before it can be stated certainly that bacilli are absent. The presence of bacilli proves the diagnosis, but their absence does not negative it (Willy Meyer). If bacilli are not found, inject some of the urinary sediment into a guinea-pig, and note if tuberculosis arises in the animal. Czerny has shown that in cases of tuberculous kidney in which bacilli are not found in the urine, the administration of tuberculin will cause great numbers to appear. This agent will also cause a marked febrile reaction if tuberculosis exists. The urine may or may not be albuminous.

In many cases the kidney is obviously enlarged, and the renal area is frequently tender and occasionally painful. The patient loses flesh, and there is nocturnal fever followed by sweating. The use of the cystoscope furnishes important information. It shows from which ureter turbid urine is coming. Catheterization of the ureters should be practised by some one who is accustomed to employ it. Always examine carefully to determine if one or both kidneys are involved, if the bladder is diseased, and if the prostate gland or seminal vesicles are tuberculous.

Treatment.—Lumbar nephrectomy is not justifiable in the very beginning of a case, because such a patient may be cured by a combination of medical and hygienic treatment, and the weakening effect of the operation of nephrectomy may cause the other kidney to develop tuberculosis rapidly. Tell such a patient to lead an outdoor life. Brown recommends camp-life in the Adirondacks during the summer, and sends such patients south during the winter. If a patient cannot go to another climate, urge upon him the necessity of being much out-of-doors. Insist upon the taking of plenty of nutritious food. Courses of creasote or guaiacol carbonate are given by some.

If the kidney is markedly enlarged; if there is profuse hematuria; if the fever is high and persistent; if only one kidney is involved; and if the bladder and prostate are free from disease, perform nephrectomy. In cases with involvement of the other kidney or of the genito-urinary tract lower down, nephrectomy is not justifiable, although nephrotomy for drainage may greatly benefit the patient for a time.

* F. Tilden Brown, New York Med. Jour., April 10, 1897.

Operations on the Kidney and Ureter.—Operation for Chronic Nephritis.—In 1897 Mr. Reginald Harrison advocated puncture of the kidney to relieve tension in cases of albuminuria, and in 1901 advocated incision of the true capsule of the kidney and puncture of the gland to accomplish the same purpose ("Brit. Med. Jour.," Oct. 19, 1901). Alexander Hugh Ferguson, in March, 1899, reported two cases of interstitial nephritis cured symptomatically by decapsulation and multiple punctures ("Jour. Amer. Med. Assoc.," March 11, 1899). Dr. Geo. M. Edebohls observed, between 1892 and 1897, that in certain cases of movable kidney with albuminuria the albumin and casts disappeared after nephropexy. Rose, Wolff, and Ferguson have observed the same fact. Harrison believes that renipuncture removes the symptoms by abating tension, but Edebohls concludes that nephropexy relieves the condition and possibly cures it by establishing vascular adhesions which carry an additional supply of blood. He proposed to operate for Bright's disease in 1899 ("Med. News," April 22, 1899). Edebohls deliberately operated for chronic nephritis and claims 8 complete recoveries from chronic Bright's disease ("Med. Record," Dec. 21, 1901). There can be no doubt whatever that operation is sometimes followed by polyuria, disappearance of edema and other symptoms, and apparent cure. But in some cases the disappearance of symptoms has been too rapid to permit of the assumption that new vessels have caused it. In such cases it seems much more probable that relief of tension is the real curative factor. Edebohls says that the polyuria begins about the tenth day after operation; that improvement begins in one month and is gradual; that the cure is due to vascular adhesions; that the adhesions contain more arteries than veins; that the free blood-supply absorbs exudate and products of inflammation, frees the tubes and glomeruli from pressure and constriction, causes the reestablishment of a normal circulation and the regeneration of epithelium ("Med. Record," Dec. 21, 1901).

The exact status of the operation is not as yet determined. It does, however, seem to be proved that operation is in some cases followed by apparent cure or great amelioration of the condition. Whether permanent cure is ever thus obtained is doubtful, and the part played by rest in bed and drugs in effecting an improvement must not be lost sight of. Cases with pain and bloody urine are often much improved by incising the capsule. Post-operative suppression and the anuria of acute infectious diseases may be favorably influenced by the operation. An important fact which Rovsing maintains and Edebohls proves is that chronic nephritis may be for some time a unilateral disease. (Read the views of Schmidt in "Med. Record," Sept. 13, 1902; of Rovsing, of Copenhagen, in "Mittheilungen aus den Grenzgebieten der Medicin und Chirurgie," vol. x, 1902, and editorial in "Jour. Amer. Med. Assoc.," Jan. 11, 1902.)

The operation as practised by Edebohls may be done on both kidneys at one sitting or in two séances. In some cases only one kidney is subjected to operation. Edebohls takes a very radical view and would operate on any case free from incurable complications—if an anesthetic can be given and if the life-expectancy without operation is not less than one month ("Med. Record," Dec. 21, 1901). Ether is given or nitrous oxid and oxygen. Lay the patient prone with an air-cushion under the belly

and expose the kidney by a vertical incision at the edge of the erector spinæ mass, which cut does not open the sheath of the muscle. Remove the fatty capsule from the true capsule, continuing the dissection around each pole until the pelvis of the kidney is reached. The kidney is extruded from the wound, the true capsule is incised along the convex border and around each pole, is separated from the kidney, and is cut away close to its junction with the kidney pelvis. The kidney is then returned to its bed of fat, and the wound is closed. (See "Med. Record," Dec. 21, 1901.) Edebohls does not drain unless there is considerable edema. Edebohls reports 18 operations without a death. In 9 of the cases the operation was done more than one year ago, and 8 of them are said to be cured.

Nephrotomy.—Nephrotomy means incision of a kidney, but the term is sometimes, though wrongly, applied to the exploratory exposure of the kidney without incision. When the kidney wound is left open, as it almost invariably is, the operation should be called **nephrostomy.** The operation is employed to evacuate infectious material, relieve tension, permit of the removal of a calculus or exploration of the ureter, and for diagnosis of renal disease. The *instruments* required are scalpels, a blunt-pointed bistoury, dissecting-forceps, toothed forceps, a grooved director, hemostatic forceps, spatulæ, metal retractors, a fountain syringe, an Allis dissector, Hagedorn needles, and an Abbe needle-holder. If looking for a stone, have a large harelip-pin to sound with, forceps and a scoop to remove the stone, and a periosteum-elevator to scrape away adherent calculi. The patient lies upon the sound side, a sand-pillow being placed under the loin. The *incision* is made half an inch below the last rib and close to the outer border of the erector spinæ mass, and runs obliquely downward and forward toward the iliac crest for three inches, the incision being enlarged later if required. Divide the skin, the superficial fascia, the fat, the external oblique, the posterior border of the internal oblique, and the outer edge of the latissimus dorsi. This incision exposes the lumbar fascia. Push aside the last dorsal nerve and incise the lumbar fascia, when the perirenal fat will bulge into the wound. Two distinct layers of fat exist. Tear this fat through with dissecting-forceps or with an Allis dissector to expose the kidney, which can now be opened while it is forced into the wound by the hand of an assistant making abdominal pressure.

Kocher's incision for nephrotomy is begun in the angle between the sacrolumbalis muscle and the twelfth rib, and is carried downward, forward, and outward to the axillary line (Fig. 191). This incision divides the skin, subcutaneous tissues, lumbar fascia, the latissimus dorsi and the serratus posticus inferior muscles.

Edebohls's method enables the surgeon most thoroughly to explore the kidney, because this organ is brought outside of the body. The patient lies prone, with a large cylindrical inflated rubber pad beneath his abdomen. A vertical incision is made close to the border of the erector spinæ muscle, from just below the last rib to just above the iliac crest. The sheath of the muscle is not opened. The fibers of the latissimus dorsi are separated by blunt dissection. The iliohypogastric nerve is found and retracted. The transversalis fascia is incised and the fatty capsule reached. The two layers of the fatty capsule are torn through and the kidney exposed. The fatty capsule is *well separated* from the kidney front and back. The patient is

pulled by the legs toward the foot of the table, the pad remaining stationary. This change of position brings the pad beneath the chest, abdominal respiration takes place, the kidney is forced into the wound, and can be easily withdrawn and thoroughly examined.

Nephrolithotomy.—In this operation the incision is the same as in nephrotomy. If the kidney is not much enlarged, it can be brought out by Edebohls's method. Feel the kidney for a stone, or, if this procedure fails, explore with a needle or a pin. If no stone is found, open the pelvis, let an assistant grasp the pedicle with his fingers or with a pair of forceps, each blade of which is covered with a bit of rubber tube, while the surgeon opens into the kidney and explores with the finger. If a stone is detected by a pin or by palpation, open the kidney tissue, loosen the calculus with the nail, and remove it with the finger, with a scoop, or with forceps. After removing the stone suture the incision with catgut, and release the pressure on the pedicle. Hemorrhage will rarely occur. If in spite of this plan bleeding occurs, take out the stitches and apply pressure and hot water, or in some cases plug with iodoform gauze for twenty-four hours. When hemorrhage ceases, put a large drainage-tube down to the kidney. Close the wound in the muscles and integument and dress antiseptically. The dressings must be changed frequently and the tube should be shortened daily.

Nephrectomy.—Nephrectomy is the removal of a kidney. There are two methods of nephrectomy, the *lumbar* and the *abdominal.* Before performing nephrectomy ascertain the competence of the kidneys. If at least 1 per cent. of urea is not being excreted, it is very unsafe to operate. Be sure the patient possesses two kidneys. Examination of the bladder by cystoscope will show the ureteral orifices, a strong indication that both kidneys are present. Nevertheless, when we reflect that a horseshoe kidney has two ureters, the proof is not absolute. Catheterization of the ureters is advisable if it can be performed, but it will probably require a specialist to perform it. Proof absolute of the presence of two kidneys consists in feeling both of them. If in doubt as to the question, and if uncertain as to the competence of the organ which is to be left, feel each kidney during the operation and before removing either, or perform a preliminary exploratory laparotomy.

Lumbar Nephrectomy.—The instruments required for this operation are scalpels, a blunt-pointed bistoury, forceps as used in the preceding operation, a clamp, retractors, spatulæ, blunt hooks, an aneurysm-needle, a pedicle needle, a grooved director, stout silk, an Allis dissector, sharp spoons, and a Paquelin cautery. The patient is placed on the sound side and a pillow is placed under the loin. Several incisions have been proposed. In many cases the oblique incision is first made to permit of exploration. This incision is begun half an inch below the last rib and by the edge of the erector spinæ muscle, and is carried downward and forward toward the iliac crest. In some cases a kidney can be removed through this cut. In other cases the cut must be enlarged. It can be enlarged by extending the cut downward. Morris enlarges it by adding to it a vertical incision, which begins one inch below the origin of the oblique cut. König's incision for nephrectomy consists of a vertical cut by the edge of the erector spinæ, carried almost to the iliac crest, from which point it is curved forward toward the umbilicus, and is carried to or even through the rectus muscle. After thorough ex-

posure lift the kidney and separate it from the peritoneum; if possible, with the finger; clamp the pedicle; pass an armed aneurysm-needle between the vessels of the pedicle; ligate in two places; cut between the threads; and arrest hemorrhage permanently by ligation of each vessel. If the ureter be healthy, ligate it with silk and drop it back; if it be foul and purulent, scrape it with a sharp spoon, wash it with corrosive sublimate, and touch it with pure carbolic acid, and then either ligate it and drop it back or sew it into the wound. If hemorrhage persists from the wound, plug with gauze. Insert a drainage-tube and close the wound. If the peritoneum be accidentally opened, close it with Lembert sutures. Kocher's method is excellent, and enables the surgeon to feel the opposite kidney before removing the one which is known to be diseased. The incision is begun as described on page 1117, and is carried forward so as to expose the reflection of the peritoneum onto the colon in the posterior axillary line (Fig. 191).* At this point the peritoneum is opened, and the surgeon's hand is inserted into the abdominal cavity and feels the other kidney. If another kidney exists and it is found to be healthy, the diseased organ may be removed.

Abdominal nephrectomy is more dangerous than the lumbar operation. The same instruments are required as are used in the preceding operation. The position is supine. The incision is that of Langenbeck—four inches long in the linea semilunaris, its center corresponding to the umbilicus. Open the abdomen, introduce a hand, feel the kidneys, and if both show serious disease, do not perform nephrectomy. If we decide to remove one kidney, keep the small intestine away by pads, push the colon toward the umbilicus, incise the outer layer of the mesocolon, and bare the kidney. Strip off the peritoneum from the kidney and its vessels, and ligate the vessels by passing strong silk through the center of the pedicle with an aneurysm-needle. Ligate the ureter if healthy, and divide it. If the ureter is septic, fasten it to an opening made in the loin by cutting onto forceps pushed to the outer edge of the quadratus lumborum. Stop bleeding, irrigate the belly-cavity, and dress as usual, employing drainage only when septic matter has gotten into the peritoneal cavity or when oozing is persistent.

Nephrectomy in Children.—The operation is proper in certain non-malignant troubles. Jepson did a successful nephrectomy for a congenital cystic kidney on a patient four months and fourteen days of age. Rovsing did it successfully for congenital hydronephrosis, the patient being nine months old. Roswell Park did a successful nephrectomy for congenital cystic kidney on a child twenty-three months of age. The value of nephrectomy for sarcoma is more than doubtful. The operation never really cures, and if an operative recovery is obtained, the disease appears after a time in the other kidney. Jessup performed nephrectomy in eleven children and every case died within two and one-half years of the operation. The operation often prolongs life and relieves discomfort, but does not cure.

Partial Nephrectomy.—This operation may be performed in some cases for wounds, cysts, and innocent tumors. After removing the damaged or diseased part, bleeding points are ligated with catgut. The wound-surfaces are approximated as well as possible by catgut sutures. Drainage is introduced. The value of partial nephrectomy in some cases seems certain, and

* Kocher's "Text-book of Operative Surgery."

we should apply it when possible instead of the complete operation,* except in cases of malignant disease.

Renipuncture.—This is an operation devised by Reginald Harrison for the relief of albuminuria due to elevated tension. The kidney is exposed in the loin, the capsule is incised, and punctures are made in the kidney. Simple incision of the capsule will usually relieve nephralgia. (See Operations for Chronic Nephritis.)

Nephropexy is fixation of a movable kidney. The term nephrorrhaphy, so long used for the operation, really means suturing a wound in the kidney.

The Author's Modification of the Elder Senn's Operation.—Many surgeons feel that it is not desirable to pass sutures through the kidney-substance, and I have entirely abandoned the use of them in operations for movable kidney. Urinary fistula has followed suturing. Again, the

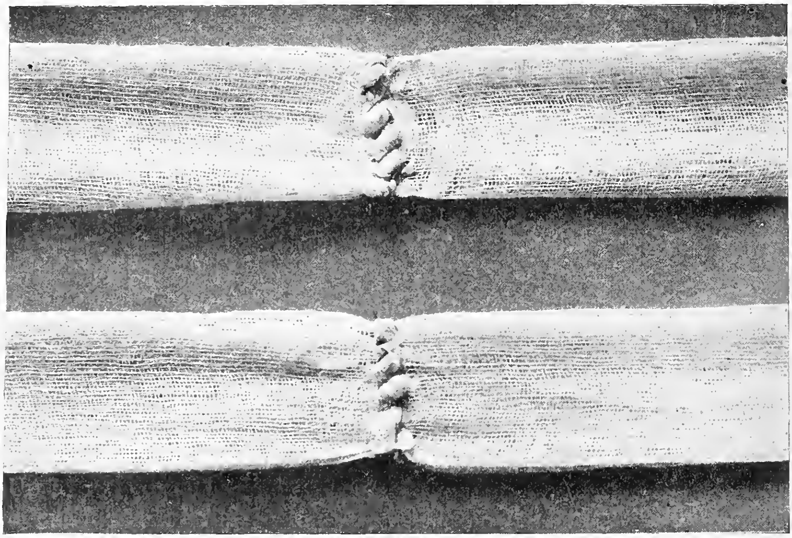


Fig. 688.—Gauze slings, each composed of two pieces sutured together with fine plain catgut.

value of such sutures is very doubtful. The kidney is a very soft organ, and if it is suspended by sutures, they are certain to cut out. In most suture operations the kidney when restored to place is not placed sufficiently high and has its ureter and vessels looking forward; in other words, there is a one-fourth twist in the ureter. In operations like Goelet's and Kelly's, which raise the kidney much nearer its proper level and which do not twist the ureter and renal vessels, the upper pole is not anchored and tends to tilt forward (page 1107). Senn's operation fixes the kidney without using sutures.

The patient lies upon his abdomen, Edebohls's bag being placed directly beneath the lower abdomen. A vertical or slightly oblique lumbar incision is made, the perirenal fat is exposed, and its two layers are torn through until the kidney is reached. The fatty capsule is thoroughly stripped from the entire

* See Oscar Bloch in Brit. Med. Jour., Oct. 17, 1896; also reports of Czerny, Bardenheuer, Tuffier, and Kümmell.

organ. The kidney is brought out of the wound. This is accomplished by pulling the patient toward the foot of the bed, so that the pad gets under the ribs, when traction on the fibro-fatty capsule will cause the kidney to emerge from the wound. The posterior fatty capsule is cut away, and also the anterior fatty capsule up to the hilum. The true capsule of the kidney is scarified or, if necessity exists, the organ is decapsulated. I always have packing prepared by suturing together with the finest plain catgut the ends of two pieces of iodoform gauze. Two such strands are prepared (Fig. 688). One piece of iodoform gauze is placed under the upper end of the kidney, and another piece under the lower end, the sling in each instance being directly under the kidney with the suture line external and not in front as the kidney protrudes from the wound in the back (Fig. 689). When the kidney is replaced, the suture line will lie in

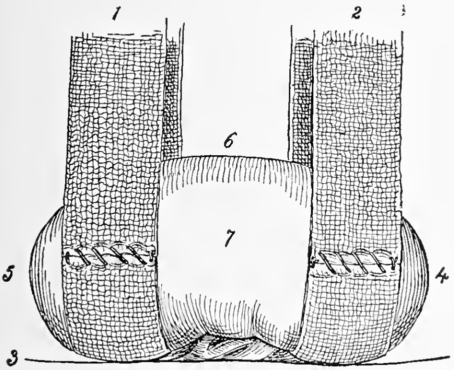


Fig. 689.—Right kidney projecting from wound. Observer standing on right side of patient: 1 and 2, Slings in place, with sutures external; 3, skin of the back; 4, upper renal pole; 5, lower renal pole; 6, convex border of kidney; 7, external surface of kidney. (Slings should be broader than is shown in cut.)

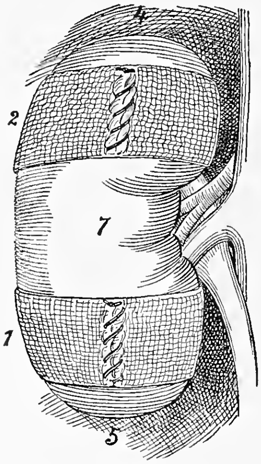


Fig. 690.—Right kidney restored to place, seen from in front: 1 and 2, Slings in place, sutures anterior; 4, upper renal pole; 5, lower renal pole; 7, anterior surface of kidney. (Slings should be broader than is shown in cut.)

front (Fig. 690). The kidney is replaced and will then lie in a sling, composed of two pieces of gauze, the ends of which protrude from the wound. Another piece is placed below the lower renal pole to fill up the space which always exists there and to stimulate granulation. This space below the kidney is a frequent cause of subsequent loosening in most suture operations, because the kidney hangs in it unsupported, as a bucket hangs in a well. Harris recognizes this, and in his operation closes the space by sutures. Gauze is packed in over and about the kidney, and over this the two long slings are tied. Several sutures are inserted to close the lumbar aponeurosis; some are tied and some are left untied. A large gauze pad is placed upon the abdomen over the anterior surface of the kidney, and the lumbar wound is dressed with gauze. The dressing and gauze pad are held in place by a binder. In about eight or ten days the gauze should be soaked with salt solution during half an hour and the packing removed. At this

time the catgut is destroyed and the gauze can be easily pulled out. The tied sutures are cut and removed, the sutures left unfastened are tied, and a small piece of gauze is inserted as a drain between the granulating surfaces. If a continuous piece of gauze was used, ether must be given before removal is attempted. Further, in the old operation, a large wound was left to granulate and weeks were often required to obtain healing. In this operation the wound is usually entirely healed in from eighteen to twenty-one days. After the performance of nephropexy the patient remains in bed for three weeks. By this operation the kidney is placed in a proper situation, is surrounded with granulations, which are converted into scar-tissue, and the organ becomes encased in a box of fibrous tissue. I believe that a kidney so treated will probably remain fixed.

Ureterolithotomy.—If the stone is impacted in the upper two-thirds of the tube, make the incision advised for wounds of the ureter (page 1109). The operation is extraperitoneal. The tube is opened by a longitudinal incision. The stone is removed. The ureter is explored by means of a sound to see if it is free and is then sutured with catgut. The tissues above the ureter are sutured and a bit of rubber tissue is carried to the duct. Whenever possible—and usually it is possible—reach the ureter by the extraperitoneal route, and even well below the brim of the pelvis the peritoneum can be stripped and the ureter opened from behind. In a woman a stone near the vesical opening can be reached by a vaginal incision. If the stone cannot be reached by the extraperitoneal method, open the peritoneal cavity and incise the ureter. After removing the stone suture the wound in the ureter with silk inversion-sutures, fasten an omental graft over the suture-line (Fenger), and drain.

Uretero-ureterostomy (Van Hook's Operation).—In this operation ligate the lower end of the divided ureter with silk or catgut. About one-fourth of an inch below the ligature make an incision in the long axis of the tube. This incision is in length equal to twice the diameter of the tube. Each end of a piece of fine catgut is threaded to a fine needle. This thread is passed through the upper end of the ureter (Fig. 691). The needles are made to enter the lower end of the tube through the door made by the surgeon. They are pushed through the wall of the ureter one-half an inch below the door (Fig. 691). Traction upon the strings causes invagination, and the ligature-ends are tied. If the operation is intraperitoneal, the ureter is wrapped about with peritoneum.

Intestinal Implantation of the Ureters.—This operation may be employed in exstrophy of the bladder and in vesical cancer, in which it is necessary to remove the bladder. After this operation there is danger of infection of the ureters and consequent ascending ureteritis and pyelonephritis, and the presence of urine in the bowel usually causes inflammation of the rectum and incontinence of urine may take place.

Maydl asserts that a piece of the bas fond should be removed with the ureter, and implanted with it into the intestine, the flange hanging free in the lumen of the gut. If this is done, the relations of the ureter to the muscular coat of the bladder are not interfered with, stricture is less likely to occur, ascending infection is antagonized, and suppurative conditions arise at the margin of the flange, rather than, as in other methods, directly in the cut ureter. Maydl has collected the records of fourteen cases operated upon

by this method, with two deaths.* In vesical exstrophy Peterson transplants a vesical flap containing both ureteral orifices into the descending colon.

Cystoscopy.—Cystoscopy is the employment of the cystoscope for the study of the interior of the bladder, the prostate, the ureteral orifices, and the appearance of the fluid coming from each kidney. In order to use the cystoscope satisfactorily the urethra must admit instrument No. 24 of the French scale. In order to sterilize the cystoscope before using place it for five minutes in a 2 per cent. solution of formalin containing alcohol in the proportion of 1 to 10 (L. W. Bremerman), or place it in formalin gas. After sterilization wash it carefully with sterile salt solution. This is done to remove the highly irritant formalin. Ureteral catheters are sterilized in formalin gas and are then washed in sterile salt solution. The bladder must hold at the very least 100 c.c. of fluid. Examination is either impossible or unsatisfactory if the prostate is greatly enlarged. The following are the contraindications to cystoscopy (Follen Cabot and Henry G. Spooner, in "Med. Record," July 11,

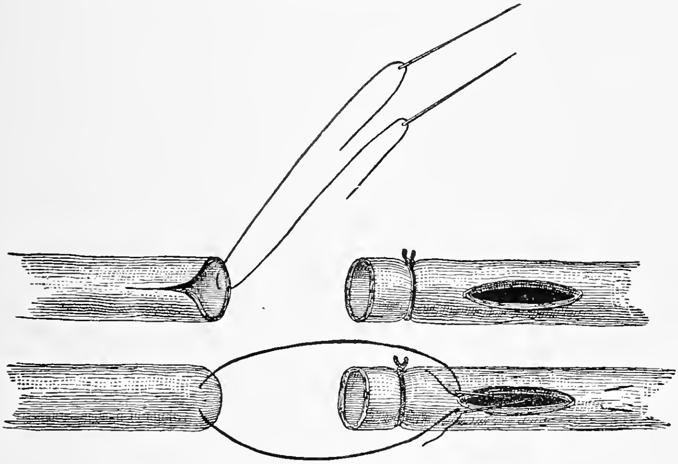


Fig. 691.—Van Hook's method of ureteral anastomosis.

1903): When it is obvious that operative intervention would be useless; when there is a very large tumor; in acute cystitis; in tuberculosis in which the diagnosis is evident without the cystoscope. The bladder may be dilated with air, Bransford Lewis's cystoscope being used (Fig. 683), or with fluid, the instrument of Nitze being employed (Fig. 692). F. Tilden Brown's cystoscope allows us to fill the bladder with fluid after it is introduced. It is desirable, if possible, to have at least 8 ounces of fluid in the bladder during catheterization. The Nitze-Albarran instrument is a very useful catheterizing cystoscope.

To arrest bleeding during the examination it may be necessary to fill the bladder with a 1 : 10,000 solution of adrenalin chlorid and retain it for three minutes.

In order to use the Nitze instrument it is rarely necessary to give ether, and, as a rule, cocain can be used. The glans penis is carefully cleansed by means of cotton soaked in boracic-acid solution, and the meatus is cleansed

*Editorial in Jour. Amer. Med. Assoc., May 6, 1899.

by irrigation with the same solution. The bladder is irrigated with boracic-acid solution until the fluid emerges clear, and is then filled with boracic-acid solution. The sterilized cystoscope is washed off in salt solution, and lubricated with yellow liquid cosmolin. The current is turned on for a moment to see that the lamp works properly. In the Nitze instrument a light of 32 candle-power is sufficient, and a rheostat is always employed. The current is turned off, the instrument is introduced, the current is turned on again, and the exploration is carefully made. If blood obscures the transparency of the fluid, withdraw the instrument, empty the bladder, fill it with adrenalin, withdraw the adrenalin in three or four minutes, fill the bladder with boracic-acid solution, and reinsert the cystoscope. If this fails, use the irrigating cystoscope, an instrument which continually changes the fluid while the examination is being made. The cystoscope is an instrument of great value in the hands of an experienced man, but is practically useless when employed

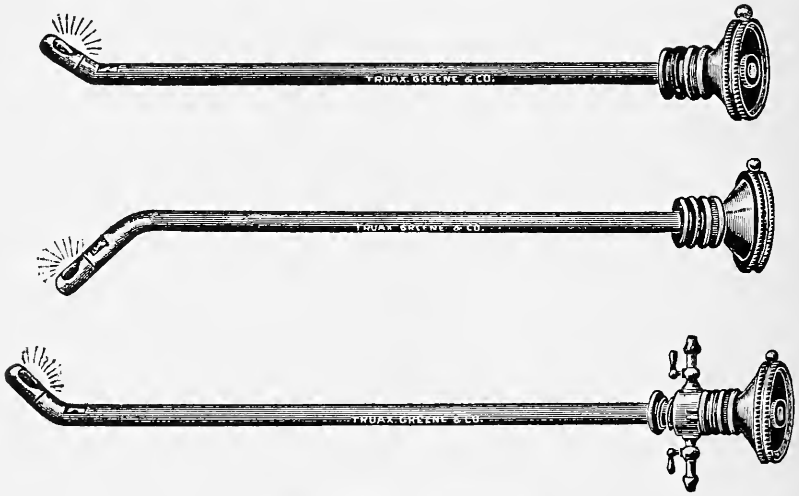


Fig. 692.—Nitze's cystoscopes.

by a novice. In using a cystoscope the mucous membrane may be burned with the lamp. This causes inflammation, and if an eschar forms, it will be cast off, exposing a granulating surface. Schmidt calls attention to this injury, speaks of the condition as *ulcer cystoscopicum*, says it is in the fundus, has the shape of the instrument, and heals in from fourteen to twenty-one days ("Jour. Amer. Med. Assoc.," July 19, 1902).

Disinfection of Catheters.—Metallic instruments are cleansed by boiling. Soft-rubber and elastic catheters can be sterilized by mechanical cleansing with soap and water and boiling for five minutes. The common custom of immersing a soft-rubber or elastic catheter for five minutes in a 1 : 2000 solution of corrosive sublimate is a useless waste of time, as such a procedure will not sterilize an infected instrument. Of course, a catheter coated with varnish or resin cannot be boiled in water or placed in steam. The best method of sterilization for woven or varnished catheters is formalin vapor. Catheters, after being cleansed mechanically, should be placed in a

glass cylinder the bottom of which is perforated like a sieve. This jar is placed for twenty-four hours in the vapor of formalin. After sterilization the instruments are kept ready for use in a glass cylinder containing calcium chlorid (R. W. Frank, in "Berliner klin. Woch.," No. 44, 1895). Before using, the catheters are washed in sterile water or salt solution. Guyon prefers to scrub catheters with soap and water, dry them outside and inside, and place them in the vapor of sulphurous acid for forty-eight hours.

Diseases and Injuries of the Bladder.

Retention of Urine in the Male.—Retention of urine is not, of course, a disease: it is rather a result of one of a number of different diseases. By this term is meant an absolute inability voluntarily to micturate. The retention may be *complete*, not a drop emerging, or it may have been complete, a dribbling setting in after a time, due to paralysis of the bladder, which viscus becomes unable to contain more fluid, expulsion of the overflow from the ureters being produced by atmospheric pressure. This condition is known as *the engorgement*, *the overflow*, or *the incontinence of retention.* There may be *retained* urine in a man with enlarged prostate, a portion only of the urine being voided. This is not retention, and the urine so retained is called *residual urine.* Of course, true retention may arise in a person with enlarged prostate. Retention may be caused by—(1) *obstruction*, resulting from urethral stricture, hypertrophied prostate, inflamed prostate, occluded meatus, impacted calculus, or foreign body, urethral tumor, rupture of the urethra, perineal abscess, imperforate prepuce, congenital phimosis, tumor of the penis, tumor of the prostate, prostatic abscess, abscess of the penis, ischiorectal abscess, and pressure from a large pelvic tumor. The commonest obstructive cause is spasm of the membranous urethra arising during the existence of stricture, acute gonorrhea, or gleet. (2) *Defective expulsion*, resulting from impairment of the nervous apparatus for inducing micturition. Hysteria is a rare cause in men. We see retention without obstruction after vertebral fractures or spinal concussion, in certain diseases of the spinal cord, sometimes in shock and peritonitis, often in the continued fevers and diseases characterized by muscular wasting, from the action of certain drugs (belladonna, opium, or cantharides), and after certain surgical operations upon or about the rectum. The last-named form of retention is due either to reflex inhibition of the expulsor muscle or to reflex stimulation of the sphincter vesicæ, causing it to remain firmly contracted. *Acute retention* comes on suddenly and is sometimes the first thing that causes a sufferer from urethral stricture to seek a surgeon.

Symptoms.—In *acute retention* there is an agony of desire to urinate, the patient making acutely painful straining efforts, during which feces are often passed. There are severe pain and aching in the abdomen, thighs, perineum, and penis. All the symptoms rapidly increase, a typhoid state is inaugurated, and death closes the scene unless relief be given. If retention is from time to time alleviated by the passage of a little water, the symptoms are slower in evolution and are less intense, and the case is said to be *chronic.* Some cases of gradual onset, due to atony, are very insidious, the patient feeling no particular pain and complaining only of the dribbling, which is

really the overflow of retention, and is not a sign that the bladder is successfully emptying itself. In any case of retention the bladder rises above the pubes, and there is found a pyriform, elastic, fluctuating mass in the hypogastrium, which mass is dull on percussion and gradually enlarges until the bladder is evacuated or incontinence sets in. The flanks give a clear percussion-note, and the tumor is more prominent when the patient is erect than when he is recumbent. Long continuation of obstructive disease, producing partial retention with or without attacks of complete retention, disorganizes the kidneys. Acute and complete retention may induce rupture of the urethra or urinary suppression.

Fig. 693.—Gouley's tunnelled catheter threaded on a filiform bougie.

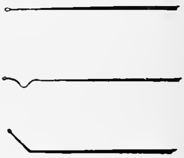


Fig. 694.— Points of Gouley's whalebone guides (filiform bougies).

Treatment.—Place the patient upon his back, keep him warm, and if instrumentation does not rapidly succeed, give an anesthetic. Never attempt to use a catheter when the patient is erect. To do so may cause serious or possibly fatal shock. Be sure that every instrument is aseptic. In *organic stricture* try to pass an elastic, olivary-pointed catheter (Fig. 696, *a*). Do not use any force until the neck of the catheter engages in the stricture. Then an experienced operator may warily use a certain amount of force, but never much. When the instrument enters the bladder, draw off but half of the urine, withdraw the instrument, wait a few hours, insert it again, and then empty the bladder and wash out the viscus with warm boric-acid solution. To

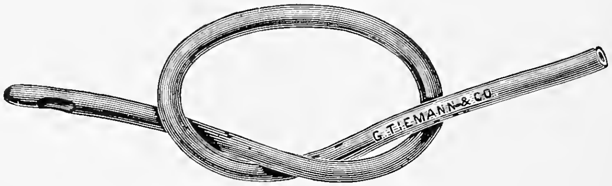


Fig. 695.—Nélaton's catheter.

draw off all of the urine at once is dangerous, because the sudden relief of the pressure upon distended veins leads to bleeding from the mucous membrane and hemorrhage into the bladder-walls. After the bladder has been emptied the patient is wrapped in blankets, a bag of hot sand or of hot water is placed against the perineum, and a hot-water bag is laid upon the hypogastric region; when he recovers from the effect of the anesthetic he is given suppositories of opium and belladonna, and tablets of salol and boric acid are administered for several days. If it is found impossible to insert a rubber instrument, make an attempt to carry a filiform bougie into the bladder. Fig. 694 shows filiform bougies. If the stricture is

known to be organic from previous history, at once insert a filiform bougie. On this bougie, after it has been inserted, Gouley's tunnelled catheter can be threaded (Fig. 693) and carried into the bladder. Instead of carrying in the catheter, we can simply leave the filiform bougie in place, and fasten it. The filiform bougie will act as a capillary drain, and in a few hours will empty the bladder. Then insert another bougie beside the first, and so on for several days, using also opium, ordering rest in bed, and making no attempt to dilate the stricture forcibly until retention has ceased and inflammation has subsided. If no bougie can be passed, aspirate or perform cystotomy (suprapubic or perineal). In *spasmodic stricture* hold a good-sized metal catheter firmly against the face of the spasmed area; relaxation will occur and the instrument will eventually pass. Fig. 697 shows the proper curve of a metal instrument. An individual who has an organic stricture which has given but little trouble may develop attacks of retention because of inflammatory edema of the mucous membrane and spasm of the urethral muscles. These attacks are temporary, and an instrument can usually be inserted when employed as above directed. In *inflammation* give a hot hip-bath and suppositories of opium and belladonna, and then use a hot sand-bag to the perineum and a hot-water bag over the hypogastrium. If these fail or if the symptoms are urgent, pass a soft catheter. In the *occluded meatus of the new-born* incise with a tenotome. In a *congenital cyst of the sinus pocularis* pass a steel bougie, which will rupture the cyst. In *complete phimosis* split up the prepuce. In *impacted stone* try to pull out the calculus with urethral forceps; if this fails, cut the urethra, or, in rare cases, push the stone back into the bladder. In *fecal impaction* scrape out the rectum with a spoon. In *enlarged prostate* try to pass an instrument of woven silk (Fig. 698) or an ordinary Nélaton catheter (Fig. 695) strengthened by the insertion of a filiform bougie nearly to the beak. If, however, the hypertrophied tissue enters markedly into the urethra, Mercier's coudé catheter is used (Fig. 696, *b*), or his double-elbowed instrument (Fig. 696, *c*). If all the above instruments fail, a metal instrument with a large curve may be employed, but it is a dangerous tool and one capable of inflicting grave injury. In *retention from expulsive defect* use a soft catheter (Fig. 695). Cases of retention after catheterization require warmth, confinement to bed, the administration of laxatives, free action of the skin, and the use of such drugs as salol, boric acid, urotropin, and quinin to asepticize the urine. In some few cases no instrument can be inserted in the bladder. In most of such cases aspirate—which may be done several times if necessary—and in a day or two, when swelling and congestion abate, an instrument can be passed. A small asepticized trocar or aspirator-needle is pushed into the bladder, the trocar or needle being inserted in the median line,

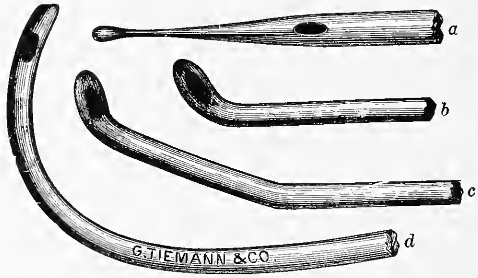


Fig. 696.—*a*, French olivary gum catheter; *b*, Mercier's elbowed catheter (coudé); *c*, Mercier's double-elbowed catheter; *d*, curved gum catheter.

just above the pubes, and taking a course downward and backward. The parts are first prepared antiseptically, and the puncture is dressed with iodoform and collodion. Only half the urine is withdrawn at a first aspiration. Rectal puncture is now obsolete. The perineal incision is the one usually employed for retention. It may be done with or without a guide. In prostatic retention, not relievable by a catheter, make suprapubic drainage or do prostatectomy.

Congenital Defects of the Bladder.—Exstrophy of the Bladder (*Ectopia Vesicæ*).—Exstrophy of the bladder is a condition of defective development commoner in males than in females. The anterior abdominal wall having failed to close, the anterior wall of the bladder being absent, and the arch of the pubes not having developed, epispadias exists, and in many cases the testicles do not descend into the scrotum. In this condition the posterior wall of the bladder projects into or beyond the gap in the abdominal wall; the urine constantly flows and renders the condition of the patient dreadful.

The only treatment which offers hope is operation, and operation often fails. If possible, operate when the patient is about five years of age. Various operations have been suggested for this condition, viz.: covering with skin-flaps; implanting the ureters into the rectum (Maydl, Albert, Roux, Simon, and others); division of the posterior ligaments of the sacro-iliac joints, bringing the arch of the pubes forcibly together, the patient wearing a support until the parts become firm, when the defect is closed in by flaps (Trendelenburg); or loosening the ureters from the bladder, drawing them down, and attaching them to the end of the penis (Sonnenberg).

Diseases and Injuries of the Bladder.—This viscus is so deeply situated, and the abdominal walls are so elastic, that it is rarely injured when empty. If the bladder be full and the abdomen be tense—which is common in alcoholic intoxication—force applied upon the abdomen may injure the bladder.

Contusion of the Bladder.—In this condition there are noted vesical hematuria, tenesmus, severe cystitis, and an impediment to the flow of water because of clots. Hemorrhage may be very severe and sepsis may arise, even causing death. When contusion exists retention is relieved by means of a clean soft catheter; if this fails because of occlusion of the eye of the catheter with blood-clot, there must, from time to time, be passed through the catheter from a fountain-syringe a solution of sodium bicarbonate in cooled boiled water. Gross's blood-catheter can be used, or the evacuator of Bigelow may be employed. The patient is put to bed, a hot-water bag is applied to the hypogastrium, morphin is administered in moderate doses, the bladder is washed out several times a day with boric-acid solution to disintegrate and remove blood-clots, and the urine is diluted and rendered aseptic by the stomach administration of salol, boric acid, and the free use of bland fluids. Hemorrhage usually ceases on relieving distention; if it does not, some more radical measure must be employed (see Hematuria).

Wounds of the Bladder.—Besides being contused, the bladder may be injured by bullets; by stabs or punctures through the abdomen, the vagina, or the uterus; or by penetration by a fragment of a fractured pelvic bone. The symptoms of such conditions are those of rupture of the bladder (*q. v.*).

In any intraperitoneal wound at once open the abdomen, suture the wound in the bladder-wall, irrigate the peritoneal cavity, and drain the bladder by means of a retained catheter, a perineal section, or a suprapubic cystotomy. In an extraperitoneal wound drain the wound by a tube, and drain the bladder by a retained catheter, a perineal section, or a suprapubic opening.

Rupture of the bladder occurs in three forms: (1) intraperitoneal—a rupture involving the peritoneal coat; (2) extraperitoneal—a rupture of a portion of the bladder not covered by peritoneum; and (3) subperitoneal—a rupture of the mucous and muscular coats, the urine diffusing under the peritoneal investment. The *causes* are of two kinds, predisposing and ex-

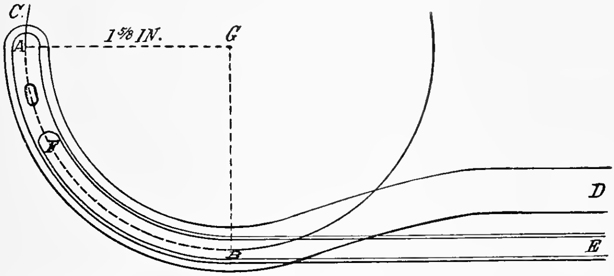


Fig. 697.—*A B E* shows the proper curve (reduced in size) for unyielding male urethral instruments; *C B D* shows an improper curve.

citing. *Predisposing* causes are: distention of the bladder; drunkenness; ulceration; degeneration or atony of the bladder-coats. *Exciting* causes are: obstruction to outflow of urine (by stricture or enlarged prostate); external violence; falls upon the feet and the buttocks, as well as upon the abdomen; lifting; straining at stool, in micturition, or during parturition; and the forcing of injections into the bladder. A distended bladder may be ruptured by a concussion. The most usual cause of the injury is a crush which forces the bladder against the sacral promontory (Alexander, in "Annals of Surgery," Aug., 1901). This accident is commoner in men than in women (10 to 1), and is rare in children.

Fig. 698.—English silk-web catheter.

Symptoms, Diagnosis, and Treatment.—The symptoms are not always definite, and every characteristic one may be for a time absent, the patient seeming in some rare instances to possess the power of retaining his urine and of voiding it. As a rule, however, there are found some or all of the following symptoms, following an accident or occurring during the progress of a causative disease: collapse; excessive desire to urinate; inability to do so; a catheter, when used, brings away pure blood or a very little bloody urine; the catheter occasionally slips through the tear into the cavity, and more bloody water comes away. In some reported cases clear water has been withdrawn. If a measured amount of boric-acid solution is injected, it is improbable that all

of it can be withdrawn by the catheter, although in some cases it may all come away (Alexander, in "Annals of Surgery," Aug., 1901). Injecting fluid fails to lift the bladder into the hypogastric region so as to be recognizable on percussion. Severe hypogastric pain and rectal tenesmus come on after a temporary sense of relief from retention. Shock is so severe that death may ensue; if reaction follows, there is delirium, often septicemia and peritonitis; extensive infiltrations of urine may occur. In *intraperitoneal rupture* general peritonitis is certain to arise, but its appearance may be postponed for several days if the urine is healthy. In these cases the extravasation is noted as a simple swelling, probably on one side only. In *extraperitoneal rupture* the urine may infiltrate the perineum, the scrotum, the thighs, and under the integuments of the abdomen and the back, and may soon induce sloughing. In *subperitoneal rupture* peritonitis is apt to arise.

In doubtful cases pump air or hydrogen into the bladder. To insert air a bicycle pump can be used (Brown), or a Davidson syringe (Keen). Keen's directions are to insert a catheter, empty the bladder of urine, and connect to the catheter a disinfected Davidson's syringe, a mass of absorbent cotton being fastened over the distal end of the syringe. Air after it has filtered through the cotton is pumped into the bladder; an unruptured bladder will rise above the pubes as a pyriform tumor, tympanitic on percussion. A ruptured bladder will not so rise. In intraperitoneal rupture the air will pass into the general peritoneal cavity and distention will occur. In extraperitoneal rupture injection will produce emphysema of the extravesical connective tissues. On removing the syringe the air rushes out again if the bladder is unruptured, but little if any comes away if it is ruptured. Alexander considers gaseous distention unreliable, and claims that it adds to shock and disseminates infection. His rule is the wisest to follow; that is, in a case of suspected rupture of the bladder, make a suprapubic incision and inspect the prevesical space for signs of extraperitoneal rupture. If extraperitoneal rupture is not found, open the belly and explore.

Treatment.—In extraperitoneal rupture after incision down to the bladder insert a drainage-tube. In intraperitoneal rupture, place the patient in the Trendelenburg position, expose the bladder by incision, and suture the opening in the viscus.

Results.—In intraperitoneal ruptures if operation is not performed the mortality is 98 per cent. If it is performed the mortality is 49 per cent. In extraperitoneal rupture without operation there are 11 per cent. cures and with operation 30 per cent. (see Daniel N. Eisendrath, "Jour. Amer. Med. Assoc.," Oct. 25, 1902; Samuel Alexander, "Annals of Surgery," Aug., 1901).

Atony of the bladder is a condition in which the expulsive power of the bladder is diminished or lost because of impairment of muscular tone. The bladder is very thin, and the muscles are flaccid and often the seat of fatty degeneration. Sometimes the viscus is very large and sometimes it is very small. A slight degree of atony is physiological after middle age. The **causes** are senility, distention from true paralysis, chronic overdistention from obstruction, and acute overdistention.

Symptoms.—In atony of the bladder the patient passes water frequently (a symptom probably existing for some years), and especially at night; he may even do so while asleep. The stream, when voluntarily passed, has no

projection, but drops at once from the end of the penis. Residual urine exists for years and may at any time set up cystitis, and retention with incontinence is apt to occur. This condition is *not* vesical paralysis resulting from a lesion of the nervous system.

Treatment.—In treating atony of the bladder measure the residual urine: if it amounts to four ounces, use a soft catheter night and morning; if it amounts to six ounces, use the catheter every eight hours; if it amounts to eight ounces, use the catheter every six hours (J. W. White). The patient should be taught how to use the catheter and how to keep it sterile. (For methods of disinfecting catheters see article on page 1124.) The bladder is from time to time washed out with gr. iij to the ounce of boric-acid solution at a temperature of 100° F. Strychnin, electricity, ergot, and urotropin may be ordered.

Vesical Calculus, or Stone in the Bladder.—The salt normally in solution in the urine may deposit as calculi and may be imprisoned in any portion of the urinary tract. The commonest calculi are those composed of uric acid, urates, calcium oxalate, and fusible phosphates. The formation of uric-acid and urate calculi is explained under Renal Calculus (page 1110). Vesical calculi are usually renal calculi that have passed the ureter and become enlarged by new accretions. Phosphatic calculi may be formed in the bladder when chronic cystitis causes and maintains an alkaline urine. Uric-acid calculi are smooth, round or oval, and hard, but easily broken. On section they present the color of brick-dust and are marked by concentric rings. Their nuclei are dark by comparison. They are soluble in dilute potassium hydrate, and with effervescence in nitric acid. They are combustible, and leave scarcely any ash. Urate of sodium and urate of ammonium often occur together in stones, and these calculi are not in rings, are not so hard as the uric-acid stones, and are fawn-colored on section. Oxalate-of-lime stones are round, with many projecting nodes like the mulberry, hence the term "mulberry calculus." They are very hard, and section shows the color to be brown or green and that they possess wavy, concentric rings. This form of calculus is soluble in hydrochloric acid. Fusible calculus, which is composed of magnesic ammonic phosphate with phosphate of lime, constitutes the commonest form of phosphatic stone and of large stone. It is light, soft, smooth, and white, and shows no laminæ on section. Some rare forms of stone are composed of xanthic oxid, cystic oxid, calcium phosphate or carbonate, and magnesic ammonic phosphate (triple phosphate).

A stone may be formed having layers of different substances; for instance, there is often found a uric-acid nucleus surrounded by phosphates, the latter surrounded by some uric acid or urates, and these again by phosphates. In some cases oxalate of lime alternates with uric acid, urates, or phosphates (Bowlby). Bowlby states that the alternating uric-acid and phosphatic layers are due to the altering reactions of the urine; that when the urine is acid uric acid is deposited on the stone, but when cystitis makes the urine alkaline the stone receives a phosphatic coat.

Anything that favors the formation of an excessive urinary deposit may cause vesical calculus, and among such causes are defective digestion, failure in processes of oxidation, excess of solids and nitrogenous elements in the diet, deficient exercise, etc. If to the urinary condition established by the above

factors catarrh of the genito-urinary tract is added, pus or mucopus in the concentrated urine may induce stone. Children are predisposed to uric-acid stones, and old people to phosphatic stones. In an old man with enlarged prostate and chronic cystitis a stone forms rapidly about any accidental nucleus. The nucleus may be phosphate crystals glued together by mucus, a blood-clot, uric-acid gravel, or a foreign body. Stone is rare in females because of the shortness, the large diameter, and the ready dilatability of the urethra. Stone is very rare in the negro. Gout, rheumatism, lithemia, enlarged prostate, vesical atony, urethral stricture, and catarrhal inflammation of the kidney, the ureter, and the bladder are predisposing causes.

Symptoms.—In not a few cases the vesical symptoms are antedated by an attack of nephritic colic. The severity of the symptoms of stone in the bladder depends more on the roughness of the stone than on its size. A small, rough calculus will produce intolerable anguish, whereas several large, smooth stones will cause but moderate pain. A patient with stone in the bladder complains of frequency of micturition, particularly in the daytime, the desire being sudden, uncontrollable, and invoked or aggravated by exercise. This symptom is more positive in youth than in old age. Pain of a sharp, burning character is experienced at the end of micturition, due to the contraction of the empty bladder upon the stone or stones. It disappears gradually as urine enters and distends the bladder. The usual seat of this pain is the under sur-

Fig. 699.—Thompson's calculus sound.

face of the head of the penis, a little behind the meatus, and the pain may continue for some time. By pulling on the penis to relieve this pain the prepuce of a child may become pendulous. This pain varies in severity, being worse during cystitis and after exercise; it may be absent in encysted stone, it may even almost disappear, and it is always worse in the young than in the old. Stone in chronic cases of atony and in cases of vesical paralysis causes neither marked pain nor frequency of micturition.* In an enlarged prostate pain *precedes* the act of micturition, in urethral stricture it *accompanies* it, and in stone, as already stated, it *follows* it. (P. J. Freyer, in "The Practitioner," Feb., 1898.) The symptoms are somewhat complicated by the coëxistence of vesical calculus and prostatic hypertrophy. Attacks of cystitis in a man with calculus are spoken of as *attacks of stone*. When a stone is small, it may during micturition roll into the urethral orifice, and so cause a sudden interruption of the flow of urine, the stream again starting when the patient changes his position. This symptom is seldom met with and is particularly rare in the old, the stone in them dropping into the sac back of the prostate and *below* the urethral orifice. Even if this symptom occurs, it is not conclusive, as a stalked tumor, a blood-clot, or a mass of pus or mucus may block the urethral orifice and cut off the stream. Hematuria may or may not be noted; it is most usual after exercise, and occurs at the end of the urinary act, the first urine passed being clear, the later urine being blood-

*"American Text-book of Surgery."

tinged, and at the end of the act some drops of pure blood emerge. It is not one of the earliest symptoms. When it occurs, it puts the patient in a great fright. It does not appear suddenly and profusely, but as gradual and trivial bleeding and with micturition. Blood appearing between acts of micturition comes from either the urethra or prostate (P. J. Freyer). The bleeding from a bladder tumor is profuse and the urine is mixed with blood and blood-clots and tumor fragments. Bleeding from a tuberculous ulcer of the bladder often resembles the bleeding caused by stone. Pus or mucopus will be observed if cystitis occurs with calculus disease. Priapism occurs in some cases. Pain of a reflex nature may be felt in the rectum, in the perineum, or in some distant part.

The above symptoms, even if all are present, do not prove that an individual has a stone in the bladder. To prove the presence of a stone, it must be touched with a sound and the contact must be felt and heard. To sound a patient, have the bladder well filled with boric-acid solution or salt solution, and place him recumbent, with the knees drawn up. Never sound a person while he is standing, because of the danger of syncope. In an ordinary case in a male use a sound with a very slight curve (Fig. 699); in a man with hypertrophied prostate use a sound with a short and decided curve. The caliber of a stone-sound is No. 13 of the French scale. The instrument is carefully boiled and anointed with yellow liquid cosmolin. Examine the entire bladder systematically, and be sure a stone is present only when contact with the sound is both heard and felt. The stone may be difficult to find, or it may elude the instrument entirely when it is encysted, when it rests in a diverticulum, when it is fixed to the roof or anterior wall of the viscus, or when it is crusted with lymph or blood-clot. In doubtful cases always insist on a second examination, giving ether if the first was very painful. Occasionally, as Freyer pointed out in 1884, a small stone will be found by using a Bigelow evacuator, the current causing the calculus to knock against the tube. In many cases stone in the bladder may be detected by means of the *x*-rays. If a stone is fixed in a diverticulum or projects from the ureter, or is in a sac back of the prostate, it may be missed by sound and evacuator tube but be shown by the *x*-rays. In such a case the bladder must be examined by means of a cystoscope. A stone, when it is detected, should always be measured by Thompson's instrument, an arrangement looking something like a small edition of a lithotrite, but having very delicate blades. The composition of the stone is assumed from an examination of fragments which pass by the urethra or which adhere to the measure. Remember that the outer layer of a calculus may be soft phosphate and the inner portion may be the harder uric acid, urate, or oxalate.

Stone in Females.—Calculus in the female is a rare complaint. In over 900 patients operated upon for stone by Freyer there were only 20 females. Pain and increased frequency of micturition, which are symptoms of stone in men and women, are in women caused by other conditions as well, notably by uterine disease and displacement. A straight sound is used to examine a female for stone. If the surgeon is still uncertain after sounding, he dilates the urethra and explores the bladder with his little finger.

Stone in Children.—Can occur at any age, and congenital cases have been placed or record. The uric-acid stone is most common. The symp-

toms are like those of the adult. The pain causes the male child to pull at the penis and the prepuce becomes pendulous. If in a child with stone the stream of urine is blocked from time to time, the child strains to empty the bladder and after a time a hernia may form or prolapse of the rectum take place.

Treatment.—In people predisposed to stone (for instance, by lithemia) the physician should foresee the danger and essay to antagonize it. Insist on the urine being kept dilute by the freest use of water and of milk, and reduce to a minimum the amount of alcohol, meat, sugar, and fat which is taken. Let the patient live chiefly on green vegetables, salads, bread, fruit, eggs, fish, poultry, weak tea or coffee, water, milk, and, if desired, a little red wine. Continued purging does harm by concentrating the urine, though a laxative may be employed when indicated. Moderate open-air exercise is of immense importance, sunshine and fresh air being nature's correctives for a condition of imperfect oxidation power. If the urine be very acid, use piperazin, gr. xv to gr. xx daily, liquor potassii citratis, phosphate of sodium, or borocitrate of magnesium. If the urine be phosphatic and alkaline, order mineral acids and strychnin, or, what seems to be very efficient, urotropin. Urotropin is given in gr. v capsules four times daily. If the urine be filled with oxalate, use the mineral acids with an occasional course of phosphate of sodium. Travel and rest at the seaside or at some spa are often of service in all forms. Always endeavor to prevent cystitis, and treat it promptly when it does occur. When a stone is once formed, it is an idle dream to think of dissolving it. An operation must be done. The operation selected depends upon the age, the state of the bladder and the prostate, the dilatability of the urethra, the kidney condition, the size and composition of the stone, and the number of calculi present (see Operations on the Bladder).

Cystitis.—Inflammation of the bladder is, as a rule, a complication of some other disease of the genito-urinary tract, but it may arise from cold and wet. Traumatism from a catheter, the presence of a stone, the spread of a urethral inflammation, pus infection, vesical tuberculosis or cancer, and the use of such a drug as cantharides may produce it. It appears not unusually during an exanthematous fever or in conditions of vesical paralysis; it often follows retention, frequently accompanies enlarged prostate and urethral stricture, and sometimes arises from concentration of urine or accompanies bladder growths. Acute cystitis causes discoloration and swelling of the bladder-walls, and there is present a catarrhal discharge which is mixed with urinary elements, serum, mucus, often pus and epithelial débris. Ulceration, sloughing, or false-membrane formation may occur. Chronic cystitis is an inflammatory condition always due to bacteria. We frequently speak of a chronic cystitis as due to stone in the bladder, hypertrophy of the prostate gland, or tumor of the bladder. These conditions do not cause chronic cystitis, but act by rendering the bladder vulnerable to micro-organisms. Among the causative organisms we may mention the bacillus coli communis, the gonococcus, the bacillus tuberculosis, the bacillus typhosus, and the various pyogenic bacteria (Leonard Freeman). These bacteria may gain entrance on instruments or by way of the ureter, urethra, the lymph-vessels, and possibly in rare instances by the blood.

In chronic cystitis there is an enormous production of thick, sticky mucus and the urine becomes alkaline. The excessive secretion of mucus and the

great number of bacteria convert the urea into carbonate of ammonium, and this product, being irritant to the bladder-walls, makes the inflammation worse. In chronic cystitis the bladder is contracted and has very thick walls, and the mucous membrane is thick, edematous, congested, and filled with large veins. The bladder may be ulcerated or encrusted with urinary salts. The urine contains bacteria, triple phosphate, pus, blood, and mucus, the blood emerging with the last drops of urine. Pyelitis may arise as a result of chronic cystitis.

Symptoms of Acute Cystitis.—Great frequency of micturition, with the passage, at each act, of a very small quantity of urine; the desire to urinate is almost constant, and there is intensely painful straining (*tenesmus*). The pain is acute and scalding, and may be felt above the pubes or in the perineum; it often runs into the loins and the thighs and radiates over the sacrum. Pain above the pubes indicates involvement of the fundus, and pain in the perineum and in the head of the penis points to inflammation of the bladder-neck. The urine, at first clear, loses its transparency, becomes full of thick mucus, and often contains a little blood or pus. The patient not unusually has some fever. A rectal examination causes violent pain. If ischuria takes place, there will be a chill and high fever, and anuria may occur or vesical rupture may ensue.

Treatment.—In treating acute cystitis endeavor to remove the cause. By allaying an irritation or removing an obstruction the bladder will often become able to empty itself of retained urine, which urine causes congestion of the bladder and thus renders infection probable or may be itself filled with bacteria. If cystitis arises from the administration of cantharides, put the patient in bed and give him liquor potassii citratis. If it comes from the use of a clean sound, order rest in bed, suppositories of opium and belladonna, diluent drinks, and ammonii benzoas or lupulin. If the inflammation is septic (as from the use of a dirty sound) or is very acute, put the patient in bed, keep him warm, and use a hot sand-bag to the perineum and hot fomentations or poultices to the hypogastrium. Hot hip-baths may be used. The hips should be elevated and the bowels should be emptied by the administration of salines and by glycerin enemata. An exclusive milk-diet is desirable. The patient should drink copiously of sweetened water containing a few drops of aromatic sulphuric acid or of milk of almonds. Sterilize the urine by the administration of urotropin, giving a capsule containing gr. $7\frac{1}{2}$ of the drug three times a day. Other remedies which may be of service in sterilizing the urine are quinin, boric acid, salol, borocitrate of magnesium, and salicylate of sodium. A valuable remedy consists of 15 grains of salicylate of sodium and 15 grains of benzoic acid, given three times a day in a little chloroform water. If the pain and straining still continue, order—

℞. Ext. hyoscyami, ... gr. viij;
Ext. cannabis indicæ, ... gr. viij;
Sacchar. alba, ... gr. xlviij.—M.
Div. in pulv. No. xxiv.
Sig.—One powder every four hours.

Or,

℞.	Camphoræ,	gr. viij;
	Ext. cannabis indicæ,	gr. viij;
	Sacchar. alba,	gr. xlviij.—M.

Div. in pulv. No. xx.
Sig.—One powder every three hours. (Von Zeissl.)

Suppositories of extract of belladonna are of great value. Suppositories each containing gr. j of ichthyol are of service, and one may be used every four hours. If these remedies fail, the surgeon will be driven to order opium, which, unfortunately, constipates; when it is given, secure evacuations by the use of glycerin suppositories, by the administration of saline carthartics, or by the employment of enemata. If opium is necessary, it is given in a suppository containing gr. j of powdered opium and gr. $\frac{1}{6}$ of the extract of belladonna every three or four hours. Hypodermatic injections of morphin may be required. Wash the bladder out daily with warm normal salt solution or warm boric-acid solution. This can be done through a soft catheter or, better, by hydrostatic pressure. If retention occurs, use a soft catheter. If much blood is passed, give internally the tinctura ferri chloridi and blister the perineum. A very acute cystitis is rarely arrested within a week or ten days.

Symptoms of Chronic Cystitis.—This condition may be a legacy from acute cystitis or it may appear without any acute precursory phenomena. There will be found frequency of micturition, but not so great as in the acute form. There will be slight tenesmus and moderate pain from time to time, radiating toward the head of the penis. Constitutional symptoms arise only when kidney-damage has become pronounced or sepsis has occurred from absorption. The urine is ammoniacal, fetid, and turbid; it is filled with viscid, tenacious mucus or with mucopus; it contains a great excess of phosphates, and occasionally clots of blood. The condition of chronic cystitis with the production of immense quantities of thick mucus is often called "*chronic catarrh of the bladder.*" Chronic cystitis may eventuate in the formation of stone or in the production of serious disease of the bladder, the ureters, and the kidneys. It often occasions retention.

Chronic Tuberculous Cystitis.—Chronic cystitis may be due to tuberculosis. Primary tuberculosis is very uncommon. Most cases of vesical tuberculosis are secondary to renal tuberculosis or to tuberculosis of the prostate, seminal vesicles, or epididymis. Some cases come on suddenly, many tubercle bacilli being found in the urine. In many cases no tubercle bacilli are found. The tuberculous products caseate and ulcers form or fibrous organization takes place. A cystitis for which no cause can be found, and which is accompanied by pyuria and severe and lasting pain, is possibly tuberculous. Pyuria is usually present, but in some cases the urine is perfectly clear. In some cases the patient has painful paroxysms of varying duration and feels well between the attacks. Finding tuberculosis, if of the kidney, prostate, vesicle, or epididymis, increases the probability that tuberculous cystitis exists. The diagnosis is made by the cystoscope. Tuberculous ulceration is most common in the trigone and about the inner orifice of the urethra. A tuberculous ulcer is small. The adjacent mucous membrane is not inflamed, but contains grayish-white nodules (Louis E. Schmidt, in "Jour. Amer. Med. Assoc.," July 19, 1902).

Treatment.—In treating chronic cystitis remove the cause, if possible (get rid of a stone, evacuate residual urine frequently, dilate a stricture, and remove a tumor). For chronic cystitis certain remedies are taken by the mouth. Water is drunk in large amounts, also iron spring-water (Marienbad, etc.). Salol and boric acid, gr. v of each four times a day, are very valuable. Salol in fluid extract of triticum repens does good; so does chlorate of potassium, gr. x daily. Either borocitrate of magnesium, quinin, or salicylate of sodium with benzoic acid may often be used with benefit. Alum, tannic acid, uva ursi, copaiba, cubebs, buchu, and turpentine have all been recommended, and possibly may be of some benefit. Urotropin is useful in many cases. This drug prevents the development of bacteria in the urine (Nicolaier) and antagonizes the tendency to sepsis and urinary poisoning. It is given in 5-grain capsules, from four to six being given daily. Whatever remedy is used, see that the bowels move once a day, and that the skin is active. Champagne and beer must be avoided. If residual urine gathers, a soft catheter must be regularly employed. If it is possible to introduce a catheter of considerable size, catheterization may be all that is needed in the case. In some cases of chronic cystitis the retention of a catheter from three to five weeks is of the greatest service. If the case is very severe, the bladder must be washed out daily with peroxid of hydrogen (25 to 40 per cent. solution), nitrate of silver (1 : 8000), boric acid (5 to 10 per cent.), carbolic acid (1 : 500), corrosive sublimate (from 1 : 20,000 to 1 : 5000), or permanganate of potassium (1 : 4000). If nitrate of silver or permanganate of potassium is used, first rinse out the bladder with distilled water. If any other agent is used, first wash out the bladder with either boiled or distilled water. The daily injection of a 2 per cent. solution of ichthyol may prove useful. Some surgeons occasionally employ, at intervals of a number of days, strong silver solutions (30 or 40 grains to the ounce). If a strong solution is used, after the drug flows away wash out the bladder with a solution of common salt. The bladder is usually washed out by attaching to the free end of a soft catheter, the other end of which is in the bladder, a tube which is connected with a graduated bottle, the force being obtained by elevating the reservoir (*fountain irrigation*). The bladder can be irrigated without using a catheter, the resistance of the compressor muscle of the urethra being overcome by the pressure of a column of water. The reservoir is raised to the height of six feet. The patient sits in a chair. The tube of the reservoir has upon it a clamp to control the flow, and in its end a large bulbous tip which will fill the meatus (Valentine's instrument). The tip is inserted into the urethra, the clamp on the tube is loosened, and the patient its directed to take a deep inspiration. In a short time the bladder fills with water, the tube is removed, and the patient empties the viscus naturally. In some cases it is necessary to wait quite a while for the column of water to tire out the muscle. If the fluid will not enter, direct the patient to make efforts, as in micturating, the pressure of the fluid on the anterior surface of the cut off muscles being kept up. If this fails, direct him to urinate, and then the surgeon makes another attempt to get the fluid to enter. After a little practice a patient learns how to admit the fluid.

In tuberculous cystitis Collin advises the instillation of 30 minims of the following mixture into the bladder and posterior urethra: 5 gm. of guaiacol, 1 gm. of iodoform, 100 gm. of sterile olive oil. About 30 minims of this are injected once a day. If the cystoscope discloses an ulcer and the kidney is

tuberculous, it is useless to operate on the ulcer until operation has been performed on the kidney. Sometimes cureting through a cystoscope is useful. In other cases the bladder must be opened, cureted, and drained. In ordinary non-tuberculous cystitis Collin uses a 1 per cent. solution of guaiacol carbonate in oil.

If the ordinary methods of treatment fail to cure chronic cystitis; if the bladder resents catheterization and irrigation; if in spite of irrigation the urine does not become clear; and if there are evidences of infection of the patient and breaking down of his general health, drain by perineal or suprapubic cystotomy and through the incision wash the bladder frequently and thoroughly. If the persistent cystitis is due to stricture which dilatation fails to cure, perform external perineal urethrotomy and employ perineal drainage.

Ulcer of the Bladder.—May be due to injury, cystitis, tuberculosis, malignant tumor, or gonorrhea. A form of ulceration particularly common in anemic women is a solitary, punched-out ulcer (Louis E. Schmidt, "Jour. Amer. Med. Assoc.," July 19, 1902). Ulcers may be single or multiple. Perforation may occur.

A perforation may occur into the peritoneal cavity or into the perivesical cellular tissue. In the former case, after the onset of marked hematuria, there are shock, abdominal pain, and peritonitis. In the latter case there is extravasation of urine or abscess-formation.

Tuberculous ulcer is discussed on page 1136.

Schmidt ("Jour. Amer. Med. Assoc.," July 19, 1902) points out that gonorrheal ulceration is apt to be multiple, and causes severe pain and bloody, turbid urine. As a rule, when the bladder is ulcerated, the urine contains blood, blood-clots, or tissue débris, but the urine may be clear when there is a tuberculous ulcer or solitary ulcer (Schmidt, in previously quoted paper).

Diagnosis is usually made by the cystoscope. In some cases it is made by exploratory suprapubic incision.

Treatment.—If there is one ulcer, or if there are a few ulcers, curet through an operating cystoscope (Schmidt), use irrigations, and keep the urine aseptic. In wide-spread ulceration perform suprapubic cystotomy, curet the diseased mucous membrane, and insert a drainage-tube. In some cases of malignant growth the cautery is used as a palliative measure. Perforation is treated as is rupture of the bladder (page 1129).

Tumors of the Bladder.—These growths are usually said to be very rare, but in Guyon's statistics they are found to constitute 3.9 per cent. of all cases of genito-urinary disease. They are almost 5 times as common in males as in females. They are most frequently met with between the ages of fifty and sixty, although myxoma is met with only in childhood and sarcoma is most common in the young (Lincoln Davis, in "Annals of Surgery," April, 1906). Persistent vesical irritation may, perhaps, be an element in causing tumor. Tumors of the bladder may be either innocent or malignant, the latter being the commonest. Innocent tumors which may arise from the bladder are papillomata or villous tumors, adenomata, mucous polypi (myxomata), fibrous polypi, myomata, and angiomata. Cysts may also arise. Malignant tumors are sarcoma (rare) and carcinoma (encephaloid, rare; epithelioma, common). Any tumor of the bladder, innocent or malignant, will eventually cause death if allowed to remain.

Symptoms.—The innocent tumors rarely cause cystitis or irritation,

though by obstructing the ureters or the urethra they may induce disease of the kidneys. Hematuria is almost invariably present at some time in the course of a bladder tumor. It is apt to be profuse, and the urine contains blood, blood-clots, and perhaps fragments of tumor. The bleeding is intermittent, may occur even when the patient is at rest, and, except in malignant disease, is seldom preceded or accompanied by pain. Bleeding usually occurs at the termination of micturition, the first urine being clear and the last red or clotted. Often hemorrhage is the only phenomenon produced by a papilloma or a mucous polypus. Malignant tumors cause cystitis, and the urine contains mucus, blood, and pus. The growth may become crusted with salts from the urine. Cancer is distinctly and often horribly painful. In malignant disease ulceration may occur into the peritoneal cavity or gut. A malignant tumor progresses much more rapidly than an innocent growth, although in cancer metastases are not formed so early as in some other regions. Innocent tumors are felt with difficulty with the sound, but malignant tumors are easily felt. In some cases a tumor can be detected by a bimanual examination (a finger in the rectum and the fingers of the other hand on the abdomen). Make a careful study to determine whether or not a growth has infiltrated the prostate, the seminal vesicles, the rectum, or the perivesical tissues. Bleeding follows the use of a sound. There may be difficulty in starting the stream in micturition, or there may be interruption or "*stammering*" of the stream. The urine should be examined microscopically to see if it contains villi, portions of fibroma, colonies of cancer-cells, or fragments of epithelioma. A cystoscope should be employed in order to reach a diagnosis. If the urethra is too narrow for the cystoscope, this channel must be dilated. If there is profuse bleeding, an irrigating cystoscope must be employed. In doubtful cases exploratory suprapubic cystotomy is advisable.

Treatment.—Complete extirpation of the bladder for cancer has been performed by Bardenheuer and others. It is usually done in two stages, in the first operation the ureters of a man being transplanted into the rectum, the ureters of a woman into the rectum or vagina. About three weeks later the bladder is removed. The complete procedure has been carried out successfully at one operation (Tuffier and Dujarier, "Rev. de Chir.," April, 1898). The operation of complete extirpation is of questionable value. As a rule, in cancer a surgeon contents himself with suprapubic cystotomy, removing the growth and a portion of the bladder-wall. If removal is not possible, curet, cauterize, and drain. In innocent tumor the growth and a portion of the bladder-wall are removed, usually through a suprapubic incision. The perineal operation only enables the surgeon to reach and remove growths of small size, pedunculated growths, and growths near the neck of the bladder. (See Operations on the Bladder.) Henry Morris lays down the following rule: "When an infiltrating growth is felt, *per rectum* or *per vaginam*, or with the sound, to be involving a large surface of the bladder-wall, to be infiltrating its coats, especially in the neighborhood of the ureters and neck of the bladder, no operation whatever should be proposed unless the hemorrhage is copious or the symptoms of cystitis severe, and then an incision for palliative purposes only should be made" (Treves's "System of Surgery").

Operations on the Bladder.—Lateral Lithotomy.—*Lithotomy* is the removal of a stone from the bladder. *Lateral lithotomy* is an operation which is every year becoming less popular, but which is still at times employed by surgeons, especially for stone in children. This operation

should not be performed if the stone is over two inches in its short diameter; it is rarely justifiable if the stone weighs three ounces or more (Cage); and it must not be performed for encysted stone, or on a person with a deep perineum, a narrow pelvic outlet, or an enlarged prostate. For one week before the operation keep the patient in bed, wash out the bladder daily with hot boric-acid solution, and administer salol and boric acid by the mouth, gr. v of each four times a day. The night before the operation give a saline, order a hot bath, and have the perineum, the scrotum, the buttocks, and the inner sides of the thighs cleansed and dressed antiseptically. In the morning an enema is to be given. At the time of operation the bladder should contain several ounces of boric-acid solution. The instruments required are a lithotomy knife, a straight probe-pointed bistoury, a grooved staff, a stone-sound, stone-forceps and scoops, a tenaculum, an aneurysm needle, a fountain syringe, curved needles and a needle-holder, hemostatic forceps, a tube with chemise (Fig. 175), a Paquelin cautery, a Clover crutch, and a lithotrite.

Place the patient upon his back, anesthetize him, and find the stone by sounding. If the stone is not discovered by the sound, *do not operate.* Place the buttocks so that they project beyond the edge of the table, introduce the staff into the bladder, flex the legs and thighs, and fasten the patient in the lithotomy position with a crutch. During the first incision the handle of the staff is held toward the belly; after the first cut the staff is set perpendicularly and is hooked up under the pubes. An incision is made, starting just to the left of the raphé of the perineum and one and a quarter inches in front of the edge of the anus, and passing downward and outward to between the anus and the ischial tuberosity, but one-third nearer the former than the latter. In the adult this incision is three inches long. The first incision is superficial and does not reach the staff, but it is this incision which may cut the rectum. After making the first cut the nail of the left index-finger feels for the groove of the staff, the staff is hooked up, the knife is entered into the groove and is pushed into the bladder, and as it is withdrawn the wound is enlarged. As the knife enters the bladder there is a gush of fluid. The finger follows the knife and stretches the wound, the staff is withdrawn, and the stone is felt for and extracted with forceps. Liston showed years ago the value of keeping the finger in the wound. This maneuver retains some water in the bladder, and as a consequence causes the stone to rest at the lowest part of the viscus, and when the forceps are introduced they at once come upon the stone. In withdrawing the stone make traction in the axis of the pelvis, and do not rotate the calculus until it is entirely out of the prostatic urethra. Wash or scrape away débris or incrustation from the wall of the bladder, see that no other stone is present, syringe out the viscus with warm salt solution, insert a tube, apply antiseptic dressings around the tube, and put on a T-bandage. The end of the tube which is external to the dressings is fastened to the tails of the T-bandage. A rubber cloth is put on the bed, under the body and legs, and the patient's buttocks rest upon a mass of old linen, the scrotum being raised on a pad. The knees are bent over pillows. Change the linen as soon as it becomes wet. Remove the tube in forty-eight hours. The urine begins to come by the urethra from the eighth to the twelfth day. In children the incision is not so long, it is dilated with forceps instead of with the finger,

and no tube is required. In lateral lithotomy the prostatic and membranous portions of the urethra are opened, the prostate gland is partly divided with the knife, and the wound is dilated with the finger. One objection to the operation is that it is possible to cut the rectum, and another is that inflammation may occlude the ejaculatory ducts.

Suprapubic Lithotomy.—This operation is the removal of a stone through an opening above the pubes. It is in many instances the preferable operation. The mortality of this operation is higher in children than that of lateral lithotomy; in adults and in individuals beyond middle life the mortality is decidedly less than is that following the lateral operation. It is used for the removal of multiple calculi, for very hard stones, for stones above one and a half inches in diameter, for calculi in men with enlargement of the prostate, for foreign bodies incrusted with sediment, when the perineum is deep, when the pelvic outlet is narrow, for encysted stones, for calculi associated with a vesical tumor, and when the urethra will not permit the use of a lithotrite. The patient is prepared as for lateral lithotomy, except that the pubes are shaved, and the lower part of the abdomen and the upper part of the thighs are disinfected. During the operation the penis is wrapped with a piece of antiseptic gauze. The instruments required are a scalpel, a probe-pointed bistoury, scissors, a tenaculum, blunt hooks, hemostatic forceps, retractors, dissecting forceps, a dry dissector, an electric forehead-light, a rectal bag, a brass syringe or a bicycle pump, a sound, rubber tubing, rubber catheters, stone-forceps and scoops, a bladder-tube, curved needles and a needle-holder, and a graduated glass jar for injecting the bladder.

In performing the *operation* place the patient in the Trendelenburg position. It is necessary to distend the bladder and raise it in order to have the prevesical space uncovered by peritoneum. Have an assistant oil the rectal bag and push it above the sphincters. Draw off the urine with a soft catheter, wash out the bladder with warm boric-acid solution (gr. iij of boric acid to ℥j of water), and inject the bladder with the same solution. In a child under the age of five inject three to four ounces; in an adult inject ten to twelve ounces. Withdraw the catheter and tie a tube around the penis to prevent the escape of fluid. After injecting the bladder with fluid, if the viscus is not well lifted, inject the rectal bag with water and clamp its tube with forceps. In a child inject from two to four ounces of warm water into the rectal bag; in an adult inject ten ounces. Bristow suggested the injection of air into the bladder. Some surgeons simply inject air by means of a catheter and a brass syringe or a Davidson syringe. If air is injected, a rectal bag is not used, and the patient is placed on his back rather than in the position of Trendelenburg. The best method of injecting air is that of F. Tilden Brown, by means of a bicycle pump. A catheter is introduced, the bladder is washed out, the catheter is fastened to a bandage, the bicycle pump is attached, the operation is proceeded with, and when the transversalis fascia is exposed the bladder is filled with air, the soft catheter is clamped, and the bladder is opened.* Make a three-inch longitudinal incision in the median line of the hypogastric region, terminating over the symphysis. When the prevesical connective tissue is reached, cut it. If the peritoneum should appear, push it up. Hold the wound-edges apart with retractors. The large veins are

*F. Tilden Brown, Annals of Surgery, Feb., 1897.

seen, giving the bladder a blue color. Avoid these veins if possible, but even if they should be cut bleeding will usually cease when the bladder is opened and the rectal bag is removed. Clamp bleeding vessels; catch the bladder transversely with a tenaculum at the upper angle of the wound; open the viscus in the middle line above, and cut toward the pubes; catch the edges of the bladder with hemostatic forceps, and remove the tenaculum. Explore the bladder, remove the stone or stones, scrape away incrustations, ligate bleeding vessels outside the bladder, and irrigate the viscus with hot saline solution. Introduce a tube into the bladder, and attach to its external end a long tube to siphon off the urine. The bladder can be drained very satisfactorily by Keen's siphonage apparatus (Fig. 700). Suture the muscles and fascia at the upper part of the wound. Dress with dry antiseptic gauze and a rubber-dam, the dressings and binder being split to go around the tube. Catch the urine which siphons over in a bottle containing some antiseptic fluid. Change the dressings as often as they become wet. Take out the tube in four or five days, and allow the wound to heal by granulation. The patient may get up in two weeks. Many Continental surgeons advocate immediate suture of the bladder after incision. Albert, Vincent, Bassini, DeVlaccos, and others advocate immediate suture. The suture material should be silk or catgut. After suture a catheter is kept in the bladder to drain the viscus. Immediate suture may be employed in patients of any age, but should not be used if the urine is very septic or if pyelonephritis exists. In some cases the attempted closure will fail; in others it will only partially succeed; in many it will prove successful; but even if it only partially succeeds it will tend to prevent dissemination of urine in the prevesical cellular tissue. The chief causes of death after suprapubic lithotomy are septicemia, secondary hemorrhage, cellulitis, peritonitis, and suppression of urine. J. W. White estimates the relative mortality of suprapubic and lateral lithotomy as follows: In children the suprapubic operation gives a mortality of 12 per cent., the perineal of 3 per cent. In adults the suprapubic gives a mortality of 12 per cent., the perineal from 8 to 12 per cent. In old men the suprapubic gives a mortality of 25 to 30 per cent., the perineal 30 to 40 per cent.

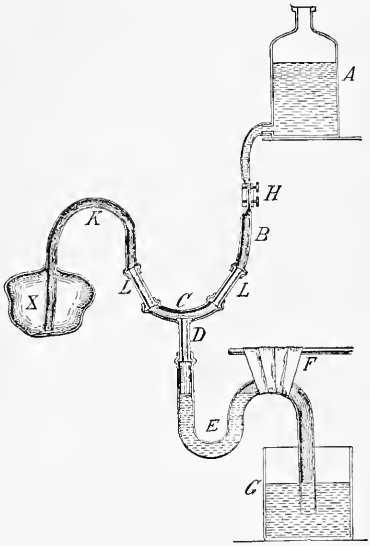


Fig. 700.—Keen's modification of Cathcart's siphonage apparatus: *X*, Cavity to be drained; *A*, reservoir; *K*, tube from cavity; *B*, tube from reservoir; *H*, clamp on tube from reservoir; *L*, *L*, *D*, glass tubes; *C*, rubber tube connecting cavity-drain with reservoir-drain; *E*, S-shaped rubber tube maintained in shape by hooking up at *F*; *G*, vessel containing antiseptic fluid.

Crushing of Vesical Calculi.—This is now done in one sitting, the old operation of Civiale, which required repeated crushings, being obsolete.

Litholapaxy (Bigelow's operation, or rapid lithotrity) is the operation for removing a stone from the bladder in one sitting by thoroughly crushing

the stone and completely washing away the fragments. This operation is wonderfully successful if done by an expert. Few of us do it sufficiently often to learn how to perform it with great rapidity, certainty, and safety. It is the best operation in most cases, if performed by a very skilful man. It is the operation in the majority of cases for even the general surgeon to select, but the general surgeon will have better results in certain difficult cases after suprapubic lithotomy than after litholapaxy. Sir H. Thompson says this method is suited to twenty-nine cases out of thirty. Litholapaxy should be employed if the bladder will hold at least four ounces of fluid and is in a fairly healthy condition; if the urethra is tolerant and penetrable by instruments; if the stone is not too hard, does not weigh over two and three-quarter ounces, and is not over two inches in diameter. It is not suited for multiple calculi, for large and hard calculi, for encysted stones, or for a patient with marked

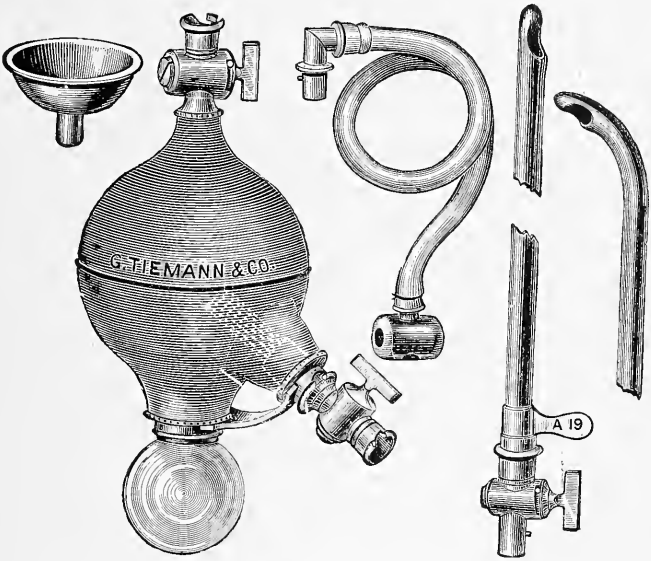


Fig. 701.—Bigelow's latest evacuator.

enlargement of the prostate gland, with vesical atony, or with cystitis. An easily dilatable stricture need not prevent the surgeon doing litholapaxy. The stricture can first be dilated, and later Bigelow's operation can be performed, but firm, gristly strictures demand a cutting operation. If the urethra is intolerant of instrumentation, the patient being prone to febrile attacks when it is attempted, cut instead of crushing. An individual laboring under kidney disease will do better after this operation than after cutting (Cage). In diabetes, locomotor ataxia, and conditions of exhaustion patients are best treated by Bigelow's operation, unless cystitis exists.

The Indian surgeons have had the most admirable results from litholapaxy. It has often been claimed that such results were due to racial peculiarities of the patients and various factors regarding their habits, diet, etc. The fact, however, that some of these very surgeons have returned to England

and repeated their successes in London, shows how large a part masterly dexterity played in obtaining success.

J. A. Cunningham * reports upon 10,073 Indian cases of litholapaxy. The mortality was 3.96 per cent.

Cabot, of Boston, in 116 cases had but four deaths, and two of these were due to pneumonia.

The preparation of the bladder is the same as for lithotomy. Be sure to measure the stone, and to ascertain also whether a lithotrite can readily be introduced and manipulated. The instruments required are a stone-sound, lithotrites (several sizes, Figs. 702–704), an evacuating bulb and tubes (straight and curved, Figs. 701, 705), soft catheters, a glass irrigator to inject the bladder,

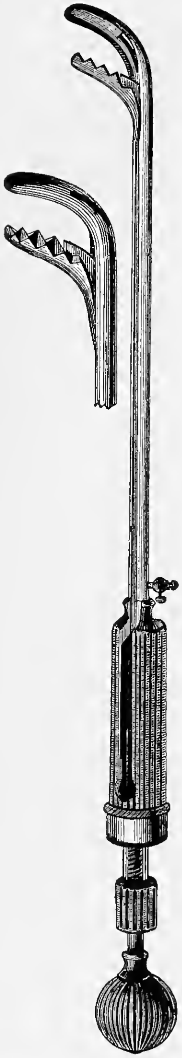


Fig. 702.—Bigelow's lithotrite.

Fig. 703.—Thompson's lithotrite.

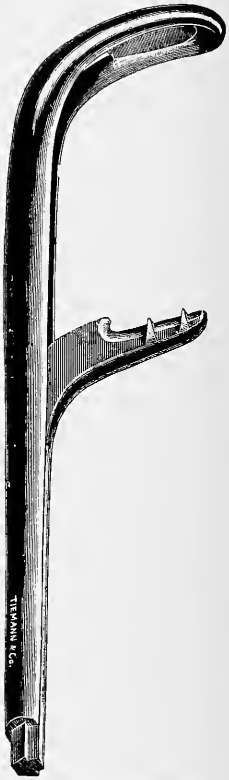


Fig. 704.—Forbes's lithotrite.

and instruments in case the surgeon is forced to cut. The patient is anesthetized and is placed upon his back, a pillow is inserted under the pelvis, and he is well wrapped up. The urine is drawn and a measured amount of warm boric acid is allowed to flow into the bladder. This

* Brit. Med. Jour., Aug. 7, 1887.

plan is better than having the patient retain his urine, as in the latter case there is no certainty as to the amount of fluid in the viscus. It is well to introduce at least five or six ounces of fluid, if possible. If the bladder will not hold four ounces the operation is unsafe (Thompson). The lithotrite, preferably the instrument of Forbes (Fig. 704), is now introduced, the handle being gradually raised to a vertical position as the penis is drawn up on the shaft, but not being depressed until the instrument has passed by its own weight into the prostatic urethra. Thompson's plan for catching the stone is as follows: After introducing the lithotrite, let its lower end rest for a few seconds on the bottom of the bladder, so that currents will subside; then draw back the male blade, wait a moment, close the blades, and in almost every instance the stone will be caught. If the stone is caught, press firmly to see that the calculus is well held, lock the instrument, and break the foreign body by screwing. When resistance suddenly ceases the stone has either slipped or has been crushed; if crushed, the blades should have been felt forcing through the stone and the calculus should have been heard to break. When resistance ceases catch and crush again as above directed. Rapid movements with the lithotrite are improper, as they establish currents which are apt to push away the stone. If the above maneuver does not catch the stone, see if the calculus be near the neck of the bladder. Pull the instrument close to the vesical neck, and open it, not by pulling the male blade, but by pushing the female blade. If the operator still fails to catch the stone, or if, after crushing, a large fragment knocks against the evacuator, which fragment cannot pass, conduct a careful search: turn the blades to the right side, open, and close; then to the left side, open, and close; next turn the point around behind the prostate and open, and close. After making a side search with the lithotrite, turn the instrument very slowly, so as to detect the catching of the bladder-wall if it has occurred, and crush the stone in the middle of the bladder with the blades up. After crushing several times, proceed to evacuate. Fill the aspirator with warm saline fluid. Insert an evacuating catheter, its point being in the center of the bladder, let the fluid and fragments run out, and attach the aspirator to the catheter; turn the valve, and compress and relax the bulb so that an ounce or more of fluid is forced in at each squeeze, the compression coinciding with expiration. The débris falls into a bulb, and the pumping is continued until the fragments cease to pass, whereupon the point of the catheter is pushed against the floor of the bladder and another trial is made. If fragments which cannot gain exit are felt knocking against the tube, withdraw the evacuator, crush

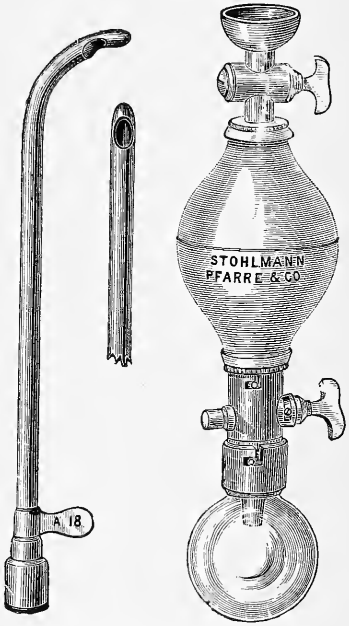


Fig. 705.—Thompson's evacuator.

again, and again use the aspirator. When no more débris comes away and no more fragments are felt, withdraw the tube and carefully sound the bladder. Keyes advises the operator to seek for a final fragment by listening with a stethoscope while pumping at the bulb and searching the bladder with the tube. This operation will rarely occupy over forty minutes, though Bigelow has protracted it for three hours, the patient recovering. A serious complication is severe bleeding, due to damage done with the instrument or to the presence of a tumor which easily bleeds. The injection of moderately hot water or of adrenalin solution (1 : 10,000) usually checks hemorrhage, but if bleeding is dangerous in amount the operation of litholapaxy should be abandoned and suprapubic lithotomy be performed.

If clogging of the lithotrite with fragments occurs, forcible pushing of the blades together repeatedly will probably amend it; but it will never happen if the surgeon uses a proper form of instrument. A lithotrite with a fenestrated blade will not lock. Forbes's lithotrite is a very powerful instrument, the blades of which will not lock. If the blades of a lithotrite should become forcibly and hopelessly locked, make a perineal section, clear out the blades, close them, and then withdraw the instrument.

After-treatment.—Put the patient to bed, apply a bag of hot water to the hypogastrium, and give him a hypodermatic injection of morphin as he recovers from ether. Give a hot hip-bath every night, and administer liquor potassii citratis in moderate doses every day. If urethral fever occurs, use quinin and morphin, wash out the bladder several times daily with warm boric-acid solution, and tie in a rubber catheter. If retention occurs, use the catheter. If cystitis appears, treat as in an ordinary case. The urine ceases to be bloody in two or three days, and the patient may get up in a week.

Litholapaxy in Male Children.—It was considered until quite recently that a child, because of the small size of the bladder, the small diameter of the urethra, and the readiness with which the mucous membrane is lacerated by even slight violence, was a bad subject for crushing. Lateral lithotomy is known to be eminently successful when performed upon children. The elder Gross did this operation upon 72 children with only 2 deaths. Keegan, however, has persuaded the profession that rapid lithotrity is perfectly applicable to children: He shows that the bladder of a child of even less than two years of age is quite large enough to allow the surgeon to manipulate an instrument; that the mucous membrane is in no danger if the operator be careful, and that the urethra is by no means so small as was supposed. The urinary meatus must often be incised, and after doing this, Keegan states, there can be passed in a boy of from three to six years a No. 7 or 8 lithotrite (English), and in a boy of from eight to ten years a No. 10 or even a No. 14. It is, however, just to state that the operation is more delicate than a like procedure on older persons, and that no one is justified in doing it who has not had considerable experience in adult cases. Furthermore, it should be noted that Keegan's mortality by this operation has been 4.3 per cent., while Gross's mortality from lateral lithotomy on children was 2.67 per cent.

Special points of litholapaxy on male children are as follows: use well-fenestrated lithotrites; have a stylet to punch out the fragments blocking the evacuator; and crush the stone to a fine mass. There can usually be employed a No. 8 lithotrite and a No. 8 evacuating-tube (English scale).

Perineal Lithotrity (Keith's Operation).—This operation is employed by some surgeons in dealing with very hard or very large calculi in male adults, or in cases in which it is impossible to introduce a lithotrite into the bladder. Keith's operation consists in opening the urethra from the perineum, passing a lithotrite through the wound, into the urethra and along the urethra into the bladder, and crushing the stone, introducing an evacuator and removing the fragments. In Keith's operation the incision is median, and opens the membranous urethra. In very large stones, Milton thinks the surgeon should open the bladder as in ordinary lateral lithotomy, introduce a lithotrite through the incision, and crush the stone before extracting it, thus avoiding the infliction of injury upon important structures.

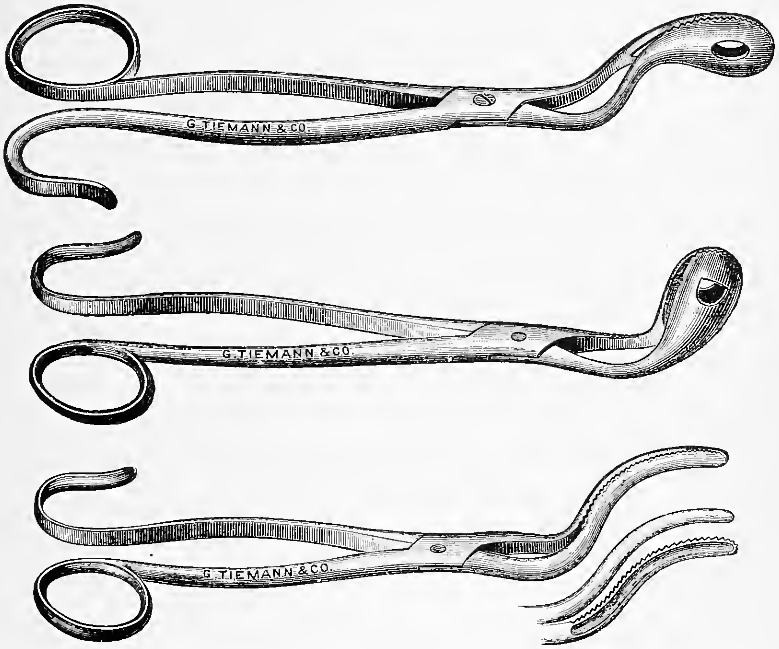


Fig. 706.—Thompson's vesical forceps for removing growths in the bladder; for growths close to the neck of the bladder, with separation of the blades, to avoid nipping the neck of the bladder.

Operation for Stone in Women.—If the stone be small, give the patient ether, place her in the lithotomy position, dilate the urethra with the uterine dilator until it admits the index-finger, and remove the stone with the finger, the scoop, or the forceps. If the stone is found to be too large to pass, crush it with a lithotrite and get rid of the débris by the evacuator. Large stones (two ounces) may require suprapubic lithotomy. Vaginal lithotomy is never required. If done, it is very likely to leave as a legacy a vesicovaginal fistula. In female children dilate the urethra, crush the stone, and evacuate.

Cystotomy.—This term means the opening of the bladder, and it is usually applied to an opening made for drainage, for diagnosis, for the removal of stones or tumors, or for the treatment of ulcers. This opening may be done by (1) a suprapubic cut (as in suprapubic lithotomy), (2) a lateral

perineal cut (as in lateral lithotomy), or (3) a median perineal cut (as in median lithotomy).

The operation may be completed in one sitting, or the bladder may be only exposed, the opening of it being delayed for several days until it becomes adherent to the margins of the wound (Senn's operation). Senn's operation prevents infiltration of urine into the prevesical space, and it is advisable to select it if the urine is very foul.

Fig. 707.—Senn's silver tube.

A sinus may persist after suprapubic cystotomy, but usually the wound heals unless it is kept open by some expedient.

The effects of suprapubic drainage are very beneficial in cases of chronic cystitis associated with hypertrophy of the prostate gland, the urine being foul. Drainage causes the urine to become clear and the mucous membrane of the bladder to become normal. If the opening is made as a permanent drain, there will usually be incontinence, as the new channel has no sphincter action (Dandridge). Figs. 707, 708, 709, 710, have tubes for prolonged drainage.

Suprapubic Cystotomy.—The operation is employed to allow the surgeon to explore the bladder, to treat an ulcer, to provide drainage, or to remove a tumor. If the operation is for calculi, it is known as suprapubic lithotomy (page 1141). After the bladder is opened its interior can be illuminated by the rays of an electric lamp, which appliance is fastened with a mirror to the forehead of the operator. If an ulcer is found, it is scraped with a curet or a spoon. Most cases of tumor require suprapubic cystotomy. It is true that a small single growth at the vesical neck is accessible by median cystotomy, but the area for manipulation is very narrow and the growth cannot be seen. Every large growth, all cases of multiple tumors, and all cases of tumor in individuals with great depth of perineum or with enlarged prostate require suprapubic cystotomy, an operation which allows one to feel and to see the growth, which gives room for manipulation, and which permits thorough exploration of the entire bladder. The patient is put in the Trendelenburg position if water distention is used, but is placed horizontally if air distention is employed. After opening the bladder as for stone

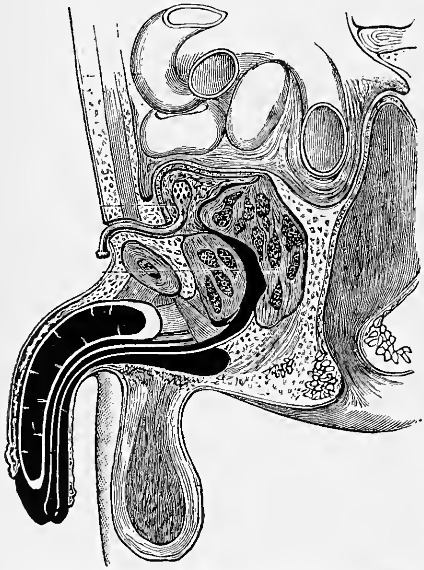


Fig. 708.—Senn's tube applied. The instrument does not press upon the sensitive neck of the bladder.

(page 1141) hold the edges of the incision apart by means of a speculum (speculum of Keen or Watson) or with retractors, and reflect the electric light into the wound. Growths when seen can be twisted off, a pair of forceps holding the base and another pair being used to twist. Broad growths should be transfixed, ligated, and severed. Some growths (as cancer) are removed piece by piece with Thompson's forceps (Fig. 706), the base of the tumor being scraped. Soft growths are scraped away with a curet, a spoon, or a finger-nail. If bleeding is severe, check it by pressure, by hot water, by a 1 : 10,000 solution of adrenalin chlorid, or even by the actual cautery. In some cases the wound is allowed to heal rapidly. In others the bladder is drained for a considerable time. In some it is kept open permanently. Permanent drainage is desirable in some cases of enlarged prostate, and in such cases Senn's tube may be employed (Figs. 707 and 708), or Stevenson's tube (Figs. 709 and 710).

Median Cystotomy.—The same incision is made in the perineal raphé in median cystotomy as for median lithotomy. A grooved staff is introduced and is hooked up under the pubes; an incision is made into the membranous urethra, and is extended backward for three-quarters of an inch, and a finger is carried into the bladder. If searching for a growth, find it with the finger, catch it with Thompson's forceps, and twist it off. Soft growths can be scraped away. Stop bleeding by digital pressure or by injections of hot water or adrenalin chlorid (1 : 10,000). If median cystotomy does not allow access to the tumor, perform suprapubic cystotomy.

Growths in the Female Bladder.—Dilate the urethra as in a case of stone, and scrape, twist, or pull the growth away or ligate it. If the growth is large or if there are multiple growths, perform suprapubic cystotomy.

Diseases and Injuries of the Urethra, Penis, Testicle, Prostate, Seminal Vesicle, Spermatic Cord, and Tunica Vaginalis.

Injuries of the penis and urethra may arise from traumatism to the perineum or the penis, from cuts and twists of the penis, from the popular "breaking" of a chordee, from tying strings around the organ, from forcing rings over it, from the passage of instruments, or from the impaction of calculi. Violence inflicted upon an erect penis may fracture the corpora cavernosa. The writer saw one man with a glass rod broken off in the canal, he having been in the habit of introducing it at the dictate of morbid sexual excitement. A patient in the Insane Department of the Philadelphia Hospital pushed a ring over his penis, which organ was lacerated into the urethra. These injuries are treated on general principles.

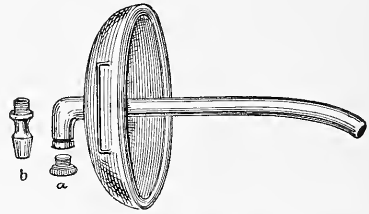


Fig. 709.—Stevenson's suprapubic drainage-tube.

Perineal Bruises.—If the perineum be bruised without rupture of the urethra, the perineum and scrotum swell and become discolored; water is passed with difficulty because the extravasated mass of blood in the periurethral tissues occludes more or less the canal; the water is not bloody; and

there are pain and profound shock. Some authors designate as rupture those cases in which laceration of the spongy tissue occurs, without involvement of the mucous membrane or of the fibrous coat, but they are properly contusions.

Treatment.—Place the patient in bed and establish reaction, and when reaction is complete employ opiates for the relief of pain. Apply an ice-bag to the perineum. If, notwithstanding these measures, swelling continues, introduce a silver catheter (No. 12 English), tie it in, and make pressure upon the perineum by a firmly applied T-bandage or by a crutch braced against the foot-board of the bed. Even when swelling is slight, retention of urine may occur from projection of a submucous blood-clot into the canal of the urethra. In some cases it may become necessary to incise and evacuate the blood-clot. After twenty-four hours have passed, if hemorrhage has ceased, substitute a hot-water bag for the ice-bag, and empty the bladder regularly with a soft catheter. Occasionally, though rarely, an abscess forms. *Punctured wounds of the urethra* require ordinary dressings. *Incised wounds of the urethra*, when longitudinal, are closed by suture. Healing is rapid, and ill consequences are not to be feared. Stricture does not follow. When the wound is transverse, introduce a catheter, suture the wound over the instrument, and remove the catheter at the end of the third day. If a catheter cannot be introduced, employ sutures, but at the first evidence of extravasation open the wound, and if drainage is not free perform external perineal urethrotomy.

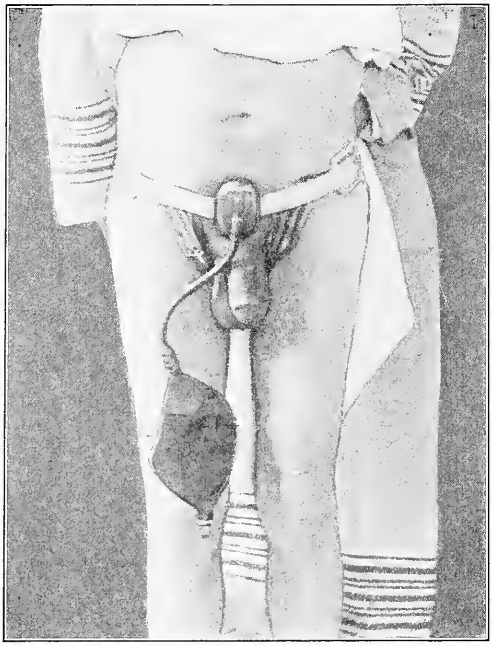


Fig. 710.—Stevenson's suprapubic drainage-tube in place and attached to a receptacle for urine.

Rupture of the Urethra.—By this term is meant a lacerated or a contused wound of the urethra, destroying partially or entirely the integrity of the canal. A lacerated wound may be induced by fracture of the cavernous bodies during erection, the symptoms being severe hemorrhage, intense pain, retention of urine, and inability to pass an instrument; infiltration of urine occurs, and gangrene is a common result. The writer has seen one case of rupture of the penile urethra due to a man's slipping while shaving, the penis being caught in a partially open drawer, the drawer being shut by his body coming against it. Rupture, however, is almost invariably located in the perineum, and it arises when the urethra is suddenly and forcibly pressed against the arch of the pubes by a blow, by a kick, or by falling astride a beam or a

fence-rail. Retention of urine due to stricture may lead to extravasation of urine. The lesion of urethral rupture consists in some cases of laceration of the spongy tissue and the mucous membrane, a cavity being formed which communicates with the canal, and which fills with urine during micturition. In other cases not only the spongy tissue and the urethral mucous membrane are rent asunder, but the fibrous coat is also torn, the canal opening directly into the perineal tissues, among which a huge cavity forms, that fills with blood and later with urine and pus. The urethra may be torn entirely across, but in most cases a small portion at least of its circumference is uninjured. Rupture never occurs primarily and alone in the prostatic urethra; it is extremely rare in the membranous urethra unless due to pelvic fracture; and it is very unusual in the penile urethra. The seat of rupture in the great majority of cases is in the region of the bulb. Very rarely is the skin broken.

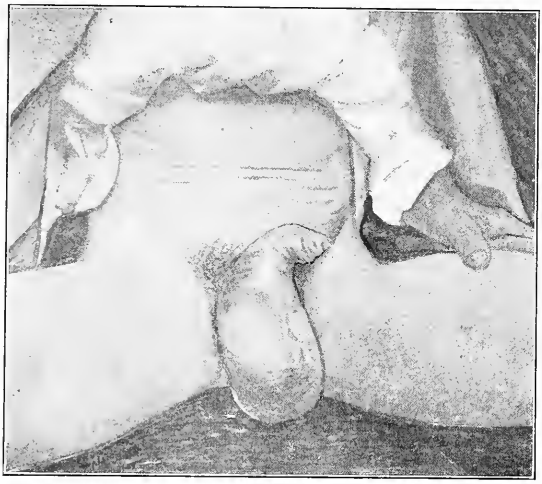


Fig. 711.—Ruptured urethra.

Symptoms.—The symptoms of rupture of the urethra are considerable pain, aggravated by motion, pressure, and attempts to pass water; great shock; in some cases micturition is still possible, blood preceding and also discoloring the stream, for some blood usually runs into the bladder; retention of urine quickly arises; in a vast majority of the cases retention is absolute from the very first, and it is due to the interruption in the integrity of the canal and to the occlusion of the channel by blood-clots. Bleeding, which is usually free, lasts for several hours, some little blood generally appearing externally and much being retained in the perineum, inducing progressive swelling. The presence of a large swelling is regarded as evidence of urethral rupture. The blood which is effused in the perineum may extend under the fascia to the penis and scrotum (Fig. 711). The swelling soon becomes reddish, purple, or even black, pressure upon it is apt to cause blood to run from the meatus, and it is augmented in volume when attempts are made to urinate. After a time, if the surgeon does not act, the urine fills the perineal cavity and widely infiltrates, and there ensue gangrene, sloughing, and sepsis, life being endangered or fistulæ being left as legacies. The course of the extravasated urine will often enable one to locate the seat of injury. In rupture of the membranous urethra, if uncomplicated, the urine remains between the two layers of the triangular ligament until a channel is opened for it by sloughing or by the knife. When extravasation occurs behind the posterior layer of the ligament the urine finds its way to the perineum in the neighborhood of

the anus. When the rupture is in front of the anterior layer of the ligament the urine, directed by the deep layer of the superficial fascia, finds its way into the scrotum and up on the belly, but does not pass into the thighs. A contusion is distinguished from a rupture by the facts that in the former the perineal swelling is not very extensive and does not enlarge on attempting micturition, while in the latter it is extensive and does enlarge on attempting to pass water. Furthermore, contusion does not cause urethral hemorrhage, while rupture does. A contusion sometimes, but not often, prevents the passage of a catheter; a rupture almost always, but not invariably, does so. The mortality from severe rupture with extravasation is about 14 per cent. (Kaufman).

Treatment.—In some cases it is possible to suture the urethra, and this procedure should be carried out when possible. In order to suture, perform suprapubic cystotomy and also make a perineal section. Find the posterior end of the ruptured urethra by passing a catheter from the bladder into the urethra. Suture with silk. The sutures pass through all of the coats of the urethra. The roof of the canal is sutured first, then a steel sound is introduced from the meatus, and the urethra is sutured around the instrument. The sound is withdrawn and the bladder is drained by Cathcart's siphon as modified by Keen (Fig. 700).* In recent cases of ruptured urethra the usual treatment is as follows: Immediately perform median perineal section and turn out the clot; trim off lacerated edges; find the proximal end of the urethra, pass a catheter from the meatus into the bladder, and leave it *in situ* until healing has begun around it. If the catheter cannot be passed from the meatus, open the bladder above the pubes and find the posterior urethra by retrograde catheterization. In retrograde catheterization we push an instrument from the bladder into the wound and use it to guide a catheter from the meatus into the bladder. When rupture occurs back of a stricture it is a good plan to excise the cicatricial tissue. In cases with extravasation make a median incision and numerous transverse cuts to secure drainage for areas of retained urine or pus. Then, at once perform suprapubic cystotomy. Drain suprapubically and from the perineum for about two weeks, by which time sloughing tissue will have separated. Then find the posterior urethra by retrograde catheterization and do a perineal operation to repair the damaged urethra. (See Eugene Fuller, in "N. Y. Med. Jour.," Nov. 23, 1901.) The wound is packed with iodoform gauze, and the bowels are tied up with opium for a few days. Many surgeons strongly disapprove of the custom of retaining the catheter, believing that the instrument does no real good, as urine is certain to get between the catheter and the walls of the urethra. In fact, it is quite enough to stuff the wound with gauze, the patient urinating through the wound for the first few days, after which time a catheter is used at regular intervals. Whatever method is employed, healing will require from six to eight weeks, and the patient must during the rest of his life, from time to time, introduce large-sized bougies.

Foreign Bodies in the Urethra.—These bodies may be calculi, bodies introduced by injury, as shot, bone, etc., bodies entering from a fistulous opening into the rectum, or bodies introduced from the meatus, as broken bits of catheters, straws, pins, etc.

* See Weir's report in Medical Record, May 9, 1896.

The **symptoms** vary with the size and the nature of the body. Sometimes there are almost no symptoms; at other times there are found great pain, retention of urine, and hemorrhage. Examination is made by feeling carefully with a finger in the rectum and by searching very gently with a sound, taking care not to push the body back. If the bladder is well filled with water when the body becomes impacted, inject a little oil into the meatus, close the lips with the fingers, and direct the patient to forcibly attempt urination, the surgeon opening the meatus when the urethra is widely distended, the foreign body being often forced out. If this maneuver fails, and the foreign body is impacted in the pendulous urethra, prevent its backward passage by at once tying a rubber tube around the penis. Try to squeeze the body out, and, if unsuccessful, endeavor to catch it with a wire loop, with a scoop, or with the long urethral forceps. If these methods fail, cut down upon the body and remove it, dividing any existing stricture. If it is lodged just back of the meatus incision of the meatus will permit extraction. If a hairpin is in the canal, the feet of the pin are almost always pointing to the meatus; to prevent them catching on attempted withdrawal, the penis must be squeezed to approximate the feet, and when they are adjacent a part of a silver catheter is slipped over to retain them in this position, when the pin can be extracted. If this fails, drag the penis against the belly, by rectal touch force the sharp ends of the pin out through the integument, cut one end off, and then withdraw the other. An ordinary large-headed pin is forced out in the same way, and when the head is turned externally it is extracted by way of the meatus. If a hard or sharp foreign body is lodged in the prostatic urethra, do not catch it with an instrument and try to drag it forward. To do so will be apt to tear the membranous urethra. It is better to push it into the bladder and remove it later by cutting, or, if it be a stone, by crushing (H. Hartmann, in "La Presse Méd.," July 24, 1901). If a lithotrite loaded with fragments be caught in the urethra, the surgeon must perform a perineal section, to enable him to clean and close the blades. After the blades have been closed the instrument may be easily withdrawn.

Urethrorrhea is not urethral inflammation, but is a condition of sensitiveness of the urethra and oversecretion of the glandular elements. It may be due to masturbation, sexual excess, and also, as Sturgis points out, to withdrawal during sexual intercourse, and to ungratified sexual passion. A drop or two of transparent mucus is found at the meatus in the morning, and a considerable amount may flow away while straining at stool or upon the diminution of an erection. This flow at stool is often called defecation spermatorrhea. This discharge stains but does not stiffen linen (Sturgis). The discharge contains mucus, mucous corpuscles, epithelial cells, sometimes spermatozoids, but no gonococci or pus organisms. The patient may be well in all other respects, but in many cases there are neurasthenic symptoms, sexual weakness, or even impotence.

Treatment.—In an uncomplicated case improvement or cure will follow upon the abandonment of evil habits. If complications arise, they must be treated.

Urethritis, or Inflammation of the Urethra.—Urethral inflammations can be divided into two classes: (1) *simple*, in which infection is due alone to pyogenic cocci (particularly the bacillus coli communis and the staphylococcus pyogenes), and (2) *specific*, in which the gonococcus is present.

Simple urethritis may be due to several causes, such as traumatism; great acidity of the urine; chancre in the urethra; contact with menstrual fluid, leukorrheal discharge, the discharge from malignant disease of the uterus, ordinary pus, or acrid vaginal discharge; the passage of instruments; the administration of irritant diuretics; strong injections; worms in the rectum; a febrile malady; venereal excess and masturbation; and the passage or impaction of foreign bodies. A temporary and mild urethritis sometimes accompanies early syphilitic eruptions. Simple urethritis is less severe and prolonged than gonorrheal urethritis, though clinically in the early stage the physician cannot invariably distinguish between the two forms. The gonococcus is never found in the discharge of simple urethritis. In the non-specific inflammation pus is not always present, many cases stopping short of pus-formation after a varying period of catarrh, but any catarrh may become purulent. A simple urethritis may be caused or may be prolonged for an indefinite period by the presence of large amounts of oxalate in the urine or the existence of the uric-acid diathesis (see Gouty Urethritis).

Treatment.—Seek for the cause and remove it. Correct any abnormal condition of the urine by means of suitable diet, drugs, and mode of life. Mild astringent injections are useful. It may be necessary to flush the urethra repeatedly with a solution of silver nitrate (1 : 8000).

Traumatic Urethritis.—The pain in traumatic urethritis is coincident with the introduction of the foreign body. The discharge, which may be bloody, mucous, mucopurulent, or purulent, comes on within twenty-four hours.

Treatment.—If the inflammation is slight, prescribe diluent drinks, paregoric, and a saline. If severe, put the patient to bed, apply hot fomentations to the perineum, give diluent drinks, employ suppositories of opium and belladonna, and watch for fever and other complications.

Gouty Urethritis.—This condition first manifests itself in the posterior urethra, not in the anterior, as does clap. Its symptoms are great vesical irritability; pain on urination; discharge, usually scanty, associated with uric acid in the urine or other symptoms of gout. The *treatment* comprises dieting and the usual remedies for gout. Purgatives are given freely, and full doses of colchicum, piperazin, urotropin, or the alkalies; hot baths, low diet, diluent drinks, and diaphoretics are indicated. A chronic discharge from the prostatic region is apt to linger; for this there is nothing better than the usual gouty remedies and saline waters with copaiba, cubebs, or sandalwood oil. In many cases it is necessary to flush the urethra once a day with a solution of silver nitrate (1 : 8000).

Eczematous Urethritis.—Berkley Hill states that this disease is very obstinate, is probably associated with gout, and is met with in adults of full habit or who are beer-drinkers and who have eczema of the surface of the body. He states also that the glans penis near the meatus is red and tender, and that the interior of the urethra is in the same condition. Pain is constant, and it is aggravated on micturition. The discharge is scanty. The *treatment* comprises injections of cold water or irrigation with iced water, and internally the administration of arsenic with the alkalies.

Tuberculous urethritis is due to a tuberculous ulcer, which is most apt to be seated near the vesical neck. There is a little pain on micturition, but

there is intense pain at one spot on passing a bougie. The discharge is slight and at times bloody. The bladder is very irritable, and severe cystitis arises and persists. The *treatment* includes warmth, nutritious diet, and cod-liver oil, removal to an equable climate, and living as much as possible out of doors. The bladder is washed out once a day with boric-acid solution. Iodoform emulsion is injected daily, but after a time the surgeon will be forced to drain by perineal or suprapubic cystotomy.

Examination when a Urethral Discharge Exists.—Learn accurately the history. Obtain some of the discharge and examine an unstained slide and a slide stained, for gonococci. In some cases take cultures. Learn the amount of the twenty-four hours' urine and study a sample chemically and microscopically, being sure to determine the amount of urea. Learn if the discharge discolors or stiffens linen; if it is only found in the morning; if it simply glues the lips of the meatus together; if it is seen during the day; if it is noted particularly or only after sexual excitement or straining at stool. Inquire as to pain, frequency of micturition, passage of blood, nocturnal emissions, manner of urinating, etc. In many cases insert a finger in the rectum, feel the prostate and vesicles, massage them, and see if discharge appears at the meatus after stripping the penis. If discharge does appear, collect a specimen and examine it. In some cases it is necessary to pass a sound. Follow Valentine's advice and cleanse the meatus, glans, prepuce, and urethra before passing a sound. Cleanse the meatus, glans, and prepuce with a 1 : 6000 solution of corrosive sublimate. Irrigate the urethra with boric-acid solution and fill the clean urethra with emulsion of iodoform and glycerin (5 per cent.), and after using the instrument irrigate again with boric-acid solution (Valentine's method). Examine the urine by the three-glass test.

The Three-glass Test (Valentine's Plan).—Take as many three-ounce tubes as are required to receive all the urine from the bladder. The first tube contains the washings from the anterior urethra. The second and other tubes, additional material from the bladder. The last tube contains material expressed from the posterior urethra, prostate, and seminal vesicles. Examine the urine and the sediment in the first two glasses and in the last glass. Note particularly if *shreds* are present. The shreds of gonorrhea are white in color and of variable length, and float in the urine. They are composed of pus-corpuscles and of epithelial cells which have undergone fatty degeneration. Many of these shreds form in the ducts of Cowper's glands, but the glands of the entire length of the urethra also furnish them.

Gonorrhea (Clap; Specific Urethritis; Tripper; Venereal Catarrh).—Gonorrhea is an acute inflammation of the genital mucous membrane, of venereal origin, due to the deposition and multiplication of gonococci in the cells of the membrane and a mixed infection with the cocci of suppuration. The disease is inaugurated by gonococci. After a few days or more secondary pyogenic infection develops and complications may result from the gonococci or from the bacteria causing the mixed infection. The disease attacks with the greatest ease surfaces covered with squamous epithelium. The gonococci enter into and multiply in the superficial epithelial and pass to between the deeper cells, where they lodge and multiply as the superficial cells are cast off. The pus from the urethra contains epithelial cells with

gonococci inside of them, and also pus-cells with gonococci within them as a result of phagocytosis. Cultures are made with difficulty. Gonococci do not stain by Gram's method but stain best with a weak, watery solution of an anilin dye. These bacteria are said not to be pathogenic to animals, although some observers deny this assertion. Gonorrhea is one of the most common and widely disseminated diseases. Probably one-half of all sterile women and many sterile men have been rendered sterile by this disease. It is responsible for not a few cases of abortion, for an enormous majority of female pelvic diseases, and it causes many cases of blindness from infection of children's eyes during delivery.

Gonorrhea in the Male.—In the male, clap begins within the meatus and fossa navicularis and extends backward throughout the length of the urethra. The mucous membrane swells and becomes hyperemic, and there is a discharge, first of mucus and serum, and then of pus. In severe cases the discharge is bloody (*black gonorrhea*). For a week or more the inflammation increases, then becomes stationary for a time, and then declines, the discharge growing less profuse and thinner, a watery discharge lasting for some little time. An ordinary case of genuine gonorrhea lasts from six to ten weeks, and even a case limited purely to the anterior urethra will rarely be cured within four or five weeks. During the acute stage the entire penis swells and the corpus spongiosum becomes infiltrated with inflammatory exudate. An interesting fact is that gonorrhea may induce mild septicemia without demonstrable complications, the condition causing, according to Thayer ("Am. Jour. Med. Sciences," Nov., 1905), a continued fever which, perhaps, lasts a number of weeks. In true gonorrheal septicemia the blood must contain gonococci. In the case recorded by Thayer and in the case recorded by Blumer and Hayes, cultures were obtained from the blood. Gonorrhea may produce grave septicemia and systemic complications. It tends particularly to attack serous membranes or other endothelial structures (joints, pericardium, endocardium, pleura, tendon-sheaths, intima of vessels, etc.). Among the complications are gonorrheal arthritis, myelitis, poliomyelitis, and multiple neuritis. There are 3 cases of gonorrheal myositis on record (Martin W. Ware, "Am. Jour. Med. Sciences," July, 1901). Phlebitis may arise. Mild endocarditis may arise or severe endocarditis may occur, identical symptomatically with ulcerative endocarditis due to other bacteria. In 6 reported cases of endocarditis gonococci were obtained by cultures from the blood *intra vitam* (Thayer, in "Am. Jour. Med. Sciences," Nov., 1905). Cerebral embolism may result. Cerebrospinal meningitis can occur (fluid obtained by lumbar puncture contains gonococci).

Gonorrheal rheumatism is discussed on page 563. Gonorrheal peritonitis is rare. Infection of the peritoneum through the blood is very rare. The majority of cases of gonorrheal peritonitis occur in women and are due to direct extension from the Fallopian tubes. Gonococci have not been found in the exudates of cases of pleuritis and pericarditis supposed to be of gonorrheal origin. A child may contract gonorrheal ophthalmia during delivery, and any person may develop it by getting gonococci into the eyes.

Symptoms of Acute Inflammatory Gonorrhea.—The period of incubation of gonorrhea is from a few hours to two weeks. The patient notices on arising a drop of thin fluid which glues together the lips of the meatus, and he feels

some heat, and itching or tickling about the meatus or in the navicular fossa. There may be uneasiness or actual pain unconnected with urination, and there is sure to be scalding pain on urination. The meatus is red and swollen, has a glazed appearance, may be covered with a little mucopus, and the lips are glued together by the discharge. It may be possible to squeeze out a drop or two. Even this early the fluid contains gonococci. The urine appears clear, but on shaking some flakes are noted. They are epithelial cells. Within forty-eight hours the *first stage*, or the stage of increase, becomes established. The meatus is now red, swollen, and everted (*fish-mouth meatus*); the entire glans may be red and swollen; if the prepuce is long, it becomes swollen, reddened, and constricted, and in many cases very edematous; the lymphatics by the frenum and on the dorsum of the penis may be red, swollen, tender, and cord-like; micturition causes severe pain (*ardor urinæ*), which is due to distention of the inflamed urethra and to stinging by the acid urine. Bumstead thus described the act of micturition in acute gonorrhea: "During the act the patient involuntarily relaxes the abdominal walls, holds his breath, and keeps the diaphragm elevated in order to diminish the pressure on the bladder and lessen the size and force of the stream" ("Venereal Diseases," by Robt. W. Taylor). Because of the narrowing of the canal the stream of urine becomes narrow, weak, twisted, forked, or is delivered in little bursts or drops. Retention may result from spasm of the muscles. When the acute stage is fully developed, the entire urethra is inflamed from the meatus to the triangular ligament; there is constant uneasiness or actual pain in the penis and perineum, increased by walking and by sitting down suddenly or carelessly. There are painful erections. Insomnia is common; *chordee* occurs, especially when the patient is warm in bed. By chordee we mean a condition of painful erection in which the penis is markedly bent. The rigid infiltration of the corpus spongiosum prevents it distending to accommodate itself to the enlarged corpora cavernosa, and in consequence the organ curves. There is frequent micturition, with tenesmus and a profuse creamy discharge, which is yellow, greenish, or even bloody. The discharge soils and stains the victim's linen and may crust upon the linen, the meatus, or the glans. The complications of this stage are *balanitis* (inflammation of the mucous membrane of the glans penis), *balanoposthitis* (inflammation of the surface of the glans and the mucous membrane of the prepuce), *phimosis* (thickening and contraction of the foreskin so that the glans cannot be uncovered), and *paraphimosis* (catching and fixation of the retracted prepuce behind the corona glandis). In the *second* or *stationary stage*, which lasts from the end of the first to the end of the second week, the acute symptoms of the first stage continue. The complications of this stage are peri-urethral abscess, lymphangitis, solitary and painful bubo of the groin, which may suppurate, inflammation of Cowper's glands, inflammation of the prostate or of the bladder, and gonorrheal ophthalmia. In the *third* or *subsiding stage* the symptoms gradually abate, the discharge becoming scantier and thinner, and finally drying up. This stage is of uncertain duration, and in it there may occur *epididymitis*, or inflammation of the epididymis. Among other possible complications we may mention gonorrheal arthritis (page 563), infective endocarditis, tenosynovitis, pyelitis, purulent ophthalmia, perichondritis, and peritonitis. Every urethral dis-

charge should be examined for gonococci in order to make a positive diagnosis. This examination is made several times during the progress of the case, so as to determine when the organisms disappear. The examination can be easily made. Place a drop of discharge upon a cover-glass, lay another cover-glass over this, and slide the glasses apart. Dry the slides in the flame of an alcohol lamp. Bring the cover-glasses in contact with a saturated solution of methylene-blue in 5 per cent. carbolic-acid water. The staining-material is allowed to remain in contact with the slides for five or ten minutes, the glasses are washed with water, are then placed in a solution of 5 drops of acetic acid to 20 c.c. of water, and kept there "long enough to count one, two, three slowly," and again washed with water. Examination with the microscope shows the gonococci stained blue.* In doubtful cases, when the microscope fails to show gonococci, make cultures. Cultures should always be taken from a discharge in a child, from the fluid of an inflamed joint, from the discharge in gleet or purulent ophthalmia, and from the blood in obscure infections.

Subacute or **catarrhal gonorrhea** develops in men who have previously had gonorrhea, as a result of prolonged or repeated coition or of contact with menstrual fluid or leukorrheal discharge. There is profuse mucopurulent discharge, very little pain on micturition, but seldom chordee or marked irritability of the bladder.

Irritative or Abortive Gonorrhea.—In this disease the symptoms, which are identical with those of beginning clap, do not increase, but are apt to disappear within ten days.

Chronic Urethral Discharges.—**Chronic urethral catarrh,** which may follow gonorrhea, is characterized by the occasional presence of a drop of clear, tenacious liquid. This discharge becomes more profuse as a result of sexual excitement or the abuse of alcohol.

The persistence of a small amount of milky discharge, because of localization of inflammation in one spot or the production of a granular patch or a superficial ulcer, characterizes chronic gonorrhea. There is some scalding on urination; erections produce aching pain; there are pain in the back and redness and swelling of the meatus. All the symptoms are intensified by sexual excitement, by coitus, by violent exercise, or by alcoholic excess.

Gleet.—If a chronic urethritis lasts over ten weeks, it is called gleet. In gleet the lips of the meatus are stuck together in the morning, and squeezing them discloses a drop of opalescent mucopurulent fluid. During the day the discharge is rarely found. The discharge is yellow or has a yellowish hue; it stains the linen distinctly, and contains pus, shreds, epithelium, and at times gonococci. The urine is clear and contains pus, gonorrheal shreds, and comma-shaped hooks. The discharge is not obviously purulent, and contains amyloid corpuscles. There are frequency of micturition, pains in the back, and dribbling of urine, and a bougie may find a stricture of large caliber, or at least will discover that the urethra is rigid from inflammatory infiltration. A discharge may be maintained by *chronic prostatitis*. In this condition there are frequency of micturition; a sense of weight or dull pain in the perineum; diminished projectile force of the stream of urine; there is often a tendency to sexual excitement and premature emis-

* Schütz's method, as set forth by R. W. Taylor in his work upon "Venereal Diseases."

sion. In prostatorrhea a milky discharge gathers in the urethra during sleep and flows during muscular effort or while the patient is at stool. The linen is stained but slightly and the lips of the meatus are not glued together on waking. There is a history of masturbation or sexual excess. The condition is not aggravated particularly by alcohol or sexual intercourse. In chronic anterior urethritis there is a discharge from the meatus or sticking together of the lips in the morning. In chronic posterior urethritis there is no discharge of pus from the meatus. If the three-glass test is made, it will be found that in a case of chronic anterior urethritis only the first portion will be cloudy and show shreds; if he suffers from posterior urethritis of not very long standing, both portions will be a little clouded, the first containing clap shreds, the last hook-shaped shreds. In a very chronic case neither sample will be cloudy, but the first portion will contain shreds. In gleet the rigidity of the urethra causes the retention of small quantities of urine after each act of micturition, back of the thickened areas. This retained urine decomposes and adds to inflammation. Indulgence in alcohol, sexual excitement, or sexual intercourse aggravates the condition.

Treatment of Acute Gonorrhea.—*General Care.*—Wash the hands after touching the parts and dry them on an *individual* towel, which is not used upon the face. Wear a suspensory bandage. Avoid violent exercise, especially bicycle riding, and also wet. Moderate exercise is allowable. The patient must not only refrain from sexual intercourse, but must not permit himself to indulge in sexual excitement, and must not drink a drop of liquor, malt, spirituous, or alcoholic. At least twice a day wash the penis in a cup of warm water containing ʒj of salt. If the foreskin is long, catch the discharge on a bit of absorbent cotton caught under the prepuce and change it at each act of micturition. If the foreskin is short, cut a small opening in a square piece of old linen, slip the linen over the glans, catch it back of corona, and bring the ends forward with the prepuce. If the glans is completely naked, pin an old stocking foot upon the undershirt, put absorbent cotton in the toe, and place the penis within this bag. Never tie or fasten any material about the penis. The patient should drink freely of plain water, of water containing a little bicarbonate of sodium, or of alkaline mineral water (Vichy or Apollinaris). He should obtain one bowel movement every day. I am accustomed to direct the patient, in accordance with Guitéras's rule (Begg, in "Phila. Med. Jour.," June 7, 1902), to avoid tea, much coffee, pickles, spices, condiments, rhubarb, tomatoes, and asparagus. Guitéras permits the moderate use of claret.

Abortive treatment may be tried if the case is seen early. The writer formerly believed that by cleansing the urethra several times a day with peroxid of hydrogen, following the hydrogen by the injection of oil of cinnamon and benzoinol, many cases of gonorrhea could be quickly aborted. Further observations confirmed by bacterial investigation have shown that he was in error. True gonorrhea cannot be aborted by the above-mentioned plan. Other abortive methods are the use of hot retro-injections of corrosive sublimate solution (1 : 20,000), two pints being run through the urethra once a day; strong injections of nitrate of silver or of tannin; scraping the meatus or the urethra adjacent with cotton, and injecting 15 drops of a 3 per cent. solution of nitrate of silver. If in seventy-two hours the symptoms are not

greatly improved, abortive treatment should be abandoned. Recent studies render it almost certain that there is no real abortive treatment. Abortive treatment, to be efficient, would have to be carried out before the gonococci penetrated the epithelial cells; in other words, would need to be instituted before the symptoms of the disease appear. Janet says that we must alter our conception as to what constitutes abortive treatment, and he doubts if a case of true gonorrhea was ever really aborted.* The method of irrigation with solutions of permanganate of potassium is really a prophylactic treatment. Janet applies his treatment as evidences of trouble present themselves, and before acute symptoms appear, and claims that in most persons the disease can be arrested in from eight to twelve days. The same plan of treatment is useful in a well-developed case.

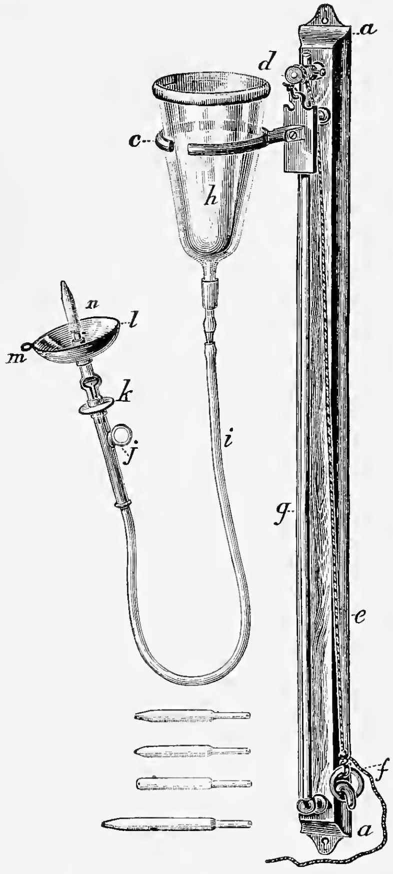


Fig. 712.—Valentine's urethral and intravesical irrigator: *a*, Board with attachments to be screwed to wall; *c*, open collar; *d*, pulley; *e*, cord; *f*, ring to suspend percolator; *g*, brass rod; *h*, percolator; *i*, rubber tube; *j*, ring for fourth finger; *k*, flange to graduate pressure; *l*, shield; *m*, ring to suspend shield; *n*, nozzle attached.

Irrigation can be used in an incipient or in a well-developed case. Janet's method is as follows: An irrigator is filled with a warm solution of permanganate of potassium (1 : 4000). The patient after emptying his bladder is seated upon a chair and his sacrum rests upon the extreme front edge of the chair (Valentine). The reservoir is joined to a glass nozzle by a rubber tube. The nozzle is introduced into the meatus, and the fluid is permitted to run gradually at first, with full force later. In anterior trouble the fluid is allowed to run out of the meatus by the side of the nozzle. The anterior urethra is always irrigated first, the reservoir being two feet above the chair.

In posterior urethritis, after the anterior urethra has been irrigated, the reservoir is raised from six to seven feet above the bed, the meatus is held tight about the nozzle, and the fluid overcomes the force of the compressor muscles of the urethra and the bladder sphincter and enters the bladder. If the muscles do not quickly relax, continue the hydrostatic pressure for several minutes, when relaxation will usually occur; but if it does not do so, tell the patient to breathe slowly and deeply, and to make efforts at urination (Valentine). When the bladder is full the tube is withdrawn and the

* Ann. d. mal. d. org. gén.-urin., 1896, p. 1031.

patient micturates. This procedure is practised once or twice a day for five or six days, or even longer, and the strength of the solution is gradually increased up to 1 : 1000. It has been claimed that after one or two weeks of this treatment gonococci permanently disappear in the majority of cases. Fig. 712 shows the irrigator devised by Ferd. C. Valentine. Valentine, of New York,* has constructed the following table, which is of use to a practitioner who wishes to employ irrigations with permanganate of potassium in the treatment of acute gonorrhea:

First day,	first visit.	Anterior irrigation	1 : 3000
First day,	7 P. M.	Anterior "	1 : 4000
Second day,	9 A. M.	Anterior "	1 : 3000
Second day,	7 P. M.	Anterior "	1 : 4000
Third day,	9 A. M.	Intravesical "	1 : 6000
Third day,	7 P. M.	Anterior "	1 : 5000
Fourth day,	9 A. M.	Intravesical "	1 : 5000
Fourth day,	7 P. M.	Intravesical "	1 : 5000
		Anterior "	1 : 2000
Fifth day,	Noon.	Intravesical "	1 : 5000
Sixth day,	Noon.	Intravesical "	1 : 5000
Seventh day,	Noon.	Intravesical "	1 : 5000
Eighth day,	9 A. M.	Intravesical "	1 : 5000
		Anterior "	1 : 3000
Eighth day,	7 P. M.	Intravesical "	1 : 5000
		Anterior "	1 : 2000
Ninth day,	9 A. M.	Intravesical "	1 : 4000
		Anterior "	1 : 1000
Ninth day,	7 P. M.	Intravesical "	1 : 4000
		Anterior "	1 : 1000
Tenth day,	9 A. M.	Intravesical "	1 : 4000
		Anterior "	1 : 1000
Tenth day,	7 P. M.	Intravesical "	1 : 5000
		Anterior "	1 : 500

For full directions regarding this method see Valentine's excellent book, "The Irrigation Treatment of Gonorrhea." If a stricture exists, it is not advisable to employ this treatment. Excellent results can be obtained by irrigations with fluid containing silver nitrate (1 : 12,000 to 1 : 8000).

When a patient is treated by irrigation, after the entire subsidence of acute symptoms, a thin, colorless discharge may persist. This can be cured by the use of astringents. Two or three times a day an astringent is injected by means of a half-ounce syringe. Dalton's formula is very useful: Zinc oxid and lead acetate, of each, $\frac{1}{2}$ gr. to 3 gr.; tincture of catechu, from ♏x to ♏xxx; glycerin, from ʒss to ʒj; and water to ℥j.

Many writers oppose the irrigation treatment, claiming that it increases the liability to complications, especially prostatic infiltration, and enhances the danger of recurrence. I believe in the method. I do not think it shortens the duration of the disease, but do believe that it mitigates its intensity, makes the patient much more comfortable, and quickly causes the discharge to become mucopurulent. That it increases complications and the danger of reinfection is very doubtful. Much of the trouble which has followed its use has been due to raising the reservoir to too great a height.

Irritative gonorrhea will subside in a few days. The above directions should be followed, and the anterior urethra should be washed out several times daily with peroxid of hydrogen, or irrigated once a day with a hot solu-

* "The Irrigation Treatment of Gonorrhea."

tion of permanganate of potassium (1 : 4000). In *catarrhal gonorrhea*, at once order injections (1 grain to the ounce of sulphate of zinc; or zinci sulphas gr. viij, plumbi acetas gr. xv, water ℥viij; or gr. v of sulphocarbolate of zinc to ℥j of water; or White's prescription of ʒj each of acetate of zinc and tannic acid, ʒiij of boric acid, ℥vj of liq. hydrogen. peroxid.). For injecting use a blunt-pointed hard-rubber syringe of a capacity of three or four drams. Let the patient urinate and then sit on a chair, his buttocks hanging over the edge; throw a syringeful of the solution into the urethra and let it run out at once and throw in another syringeful and hold it in from three to five minutes.

In *ordinary acute gonorrhea* the old rule was to order balsams. The common custom is to give two capsules three times a day, each capsule containing 5 grains of salol, 5 grains of oleoresin of cubebs, 10 grains of balsam of copaiba, and 1 grain of pepsin. Clinical observation indicates that the balsams are of distinct value in gonorrhea. When used early, the discharge tends to become mucopurulent and the acute symptoms subside (S. Behrmann, in "Dermatologisches Centralblatt," Berlin, Nov. and Dec., 1901). Many practitioners will not use balsams until the third week. Bacteriological studies indicate that copaiba, when eliminated in the urine, has a certain amount of power in inhibiting the growth of gonococci, but that cubebs and sandal have not such power. Yet sandal is more useful than copaiba as a remedy. Salol is distinctly germicidal, hence it is given with the balsams. In a case treated with balsams an astringent injection is usually employed. The injection is used two or three times a day, immediately after micturition. As the inflammation subsides increase the strength of the injection. A good plan is to order an eight-ounce bottle and eight half-grain powders of sulphate of zinc. Direct the patient to fill the bottle with water, in which one powder is dissolved; when this is used dissolve two powders in a bottleful of water, and so progressively increase the strength. When the discharge ceases stop the injections gradually. Whenever a syringeful is taken from the bottle a syringeful of water is put into the bottle, and thus pure water is soon obtained, at which point injection is discontinued. If an astringent injection causes much pain, use a sedative injection—ʒij of boric acid, gr. viij of aqueous extract of opium, and ℥viij of liquor plumbi subacetatis dilutus.

Argonin, which is a combination of albumin, silver, and an alkali, is highly recommended by some authors as a local remedy for gonorrhea (Schäffer, Guthiel). A solution of this material is non-irritant, the silver is not precipitated by chlorids, and the agent destroys gonococci. It is used by injection or irrigation. If used by irrigation, employ a 1 : 500 solution twice a day. If used as an injection, employ a 1 : 200 solution six or eight times a day. When the discharge is found free from gonococci and remains free for three days, stop the argonin and use an astringent injection.

Protargol, metallic silver combined with a proteid, is a yellow powder soluble in water, the solution not being acted on by light. It is a non-irritant germicide. Neisser, after demonstrating the presence of the gonococcus, administers protargol by injection, the first injections being of a strength of 0.25 per cent., the strength being gradually increased to 0.5 per cent., and finally to 1 per cent. In the beginning he orders three injections a day, each injection being retained from fifteen to thirty minutes; after several days, when the symptoms improve he gives only one or two injections a day,

and these are continued for ten days after gonococci disappear from the discharge. After protargol is abandoned an astringent injection should be used for a time. Some surgeons use a 1 : 1000 solution of protargol, and irrigate the anterior urethra and flush the bladder twice a day. The most powerful and useful of the silver salts is argyrol, or silver vitellin. This salt was discovered by A. C. Barnes and H. Hiller ("Med. Record," May 24, 1902). It is an extremely soluble preparation, contains 30 per cent. of silver, does not coagulate albumin, and is not precipitated by chlorids. When injected into the urethra it enters deeply into the mucous membrane and is powerful in destroying gonococci. (See "A Clinical Study of a New Silver Salt in the Treatment of Gonorrhea," by H. M. Christian, in "Med. Record," vol. lxii, 1902.) In most cases gonococci disappear within two weeks. The injection used at first may be of a strength of 2 per cent. The drug should be retained in the urethra four or five minutes, and three or four injections should be given each day. The strength of the injection can be gradually increased to 5 per cent. or even more. Picric acid has been highly commended as an injection. The strength of solution is 1 : 200, and it is to be retained in the urethra three or four minutes (de Brun's method).

Methylene-blue internally is occasionally of service in gonorrhea. A capsule containing gr. ij of the drug is given three times a day. It makes the urine greenish-blue and occasionally induces strangury. Urotropin renders the urine sterile. Salicylate of sodium may be of value late in the case.

Christian's plan of treating acute gonorrhea is very useful. It is as follows: Two solutions are used during the first ten days. Three times a day a solution of permanganate of potash is injected (gr. $\frac{1}{2}$ of permanganate of potash in 8 ounces of water), six syringefuls being used at each séance. After a washing with permanganate protargol is injected (gr. x of protargol to ℥iv of water) and retained ten minutes. At the end of four days the strength of the protargol is increased to gr. xx in ℥iv and the strength of the permanganate to 1 : 4000. During the third week abandon the above-mentioned solutions, put the patient on balsams, and use an astringent injection. Christian uses gr. x of sulphate of zinc, gr. ij of subcarbonate of bismuth, 2 ounces of solution of hydrastis, and 4 ounces of water. Cure is obtained in six or seven weeks.

Ardor urinæ is relieved by urinating while the penis is immersed in hot water and by administering an alkaline diuretic. *Chordee* requires a bowel-movement in the evening, and sleeping in a cool room, under light covers, and on a hard mattress; bromid is given several times daily, and a considerable dose is given at night; it may be necessary to use suppositories of opium and camphor or to give hyoscin. *Balanitis* requires frequent washing with warm water, drying with cotton, and dusting with borated talc or with boric acid and subnitrate of bismuth (1 : 6). *Balanoposthitis* requires soaking in hot water, applications of lead-water and laudanum, and injections of black wash under the prepuce until edema of the foreskin subsides, and then cleanliness and the application of a drying powder. *Phimosis* requires soaking the penis in hot water, injections of hot water beneath the foreskin, followed by black wash, and the use of lead-water and laudanum externally. If this fails, circumcision must be performed. If *paraphimosis* occurs, grasp the head of the penis with the left hand, squeeze the blood out, and try to push

the head back while with the right hand the penis is pulled upon, as if the surgeon intended to lift the individual by the organ. If this fails, cut the collar on the dorsum with scissors; or, what is better, for it gives free exposure, incise each side of the prepuce between the middle of the dorsum and the frenum. *Bubo* requires the application of iodin, ichthyol, or blue ointment, the use of a spica bandage, and rest. If a bubo suppurates, it must be opened or aspirated. *Acute posterior urethritis* is treated by rest, and if the symptoms are severe, by rest in bed. If the balsams do not irritate, they are given; if they do, they are withdrawn. Urotropin or salol is given and the patient is placed upon a milk-diet with orders to drink largely of flaxseed tea. Alkaline fluids do harm by favoring ammoniacal decomposition of the urine. Injections and irrigations are abandoned. Pain and vesical spasm are controlled by suppositories of opium and belladonna. If retention of urine occurs, have the patient urinate while in a hot bath; if this fails, use a soft catheter. *Acute vesiculitis* is treated as is acute prostatitis. Chronic vesiculitis is considered on page 1182. *Pyelitis* is treated by rest in bed, hot baths, wet cupping of the loin, or milk-diet, the use of diuretics, the taking of a large quantity of bland liquid, and the administration of salol or urotropin. *Folliculitis* is treated by rest and the application of a hot-water bag to the perineum (if that be the part involved). If pus forms, evacuate by incision. Later the follicle may be dissected out or destroyed by cauterization. If the follicle opens into the urethra it may be cauterized through an endoscope. *Peri-urethritis* is treated by rest and hot applications. If pus forms, an incision must be made. If the abscess is permitted to break into the urethra, rest and hot fomentations may be used, but at the first sign of urinary extravasation make an external incision. *Cowperitis* is treated in the same way as peri-urethritis. Gonorrheal rheumatism is considered on page 563. *Acute prostatitis* and *cystitis* require confinement to bed, a milk-diet, the use of diuretics, hot applications to the perineum and hypogastrium, suppositories of opium, and belladonna or ichthyol, leeching the perineum, the discontinuance of balsams and injections, and the administration of urotropin or salol. *Abscess of the prostate* requires instant incision. In *retention of urine* the patient should try to pass the urine while in a hot bath; if this fails, a soft catheter is used. After relieving the bladder put the patient to bed and apply hot sand-bags as for acute prostatitis. *Chronic prostatitis* requires cold hip-baths, cold-water enemata, deep urethral injections, plain diet, avoidance of alcohol and over-exertion, counter-irritation of the perineum, and the relief of stricture or phimosis. Great benefit is occasionally derived from passing a soft bougie covered with blue ointment or with a 10 per cent. ointment of protargol. If *epididymitis* arises, put the patient to bed, abandon injections, shave the hair from the groin, leech over the cord, elevate the testicles, and apply an ice-bag. Give a cathartic, a fever mixture, and suitable doses of bromid of potassium and morphin. The application twice a day of 20 drops of guaiacol in ʒj of cosmolin or olive oil gives great relief. When swelling lingers, after tenderness subsides strap the testicle with adhesive plaster. A lingering case is benefited by the internal use of iodid of potassium and the local application of ichthyol. In *gonorrheal ophthalmia* secure a watch-crystal over the unaffected eye, put the patient in a darkened room, rub the infected conjunctival sac with cotton soaked in a

2 per cent. solution of silver nitrate, wash out the affected eye often with hot boric-acid solution, keep the pupil dilated with atropin, leech the temple, and give purgatives. Always send for an ophthalmologist.

When is Gonorrhea Cured?—When actual discharge ceases, a patient considers himself cured and yet he may have residuals of infection which are liable at any time to awaken into activity and produce anew an acute condition. Gonococci are frequently retained in the urethral glands and follicles or in areas surrounded by indurated mucous membrane. A man is considered to be well when shreds and pus disappear from the urine, when an examination of expressed mucus on three successive days fails to find gonococci, and when there has been no discharge for ten days. Furthermore, we must be sure that the prostate, Cowper's glands, and the seminal vesicles are free from disease.

Treatment of Chronic Gonorrhea and of Chronic Urethritis following Gonorrhea.—The first thing to do is to determine the *cause* of the prolongation of the discharge. Valentine's list of causes should be borne in

Fig. 713.—Bougie-à-boule.

mind ("Med. Record," June 29, 1901). They are as follows: (1) Lack of treatment; (2) misdirected treatment; (3) insufficient treatment; (4) overtreatment; (5) infraction of dietetic or hygienic regulations; (6) constitutional disturbances; (7) congenital or acquired deformities and complications; (8) involvement of the urethral adnexa; (9) marital reinfection. In a case in which a discharge persists or recurs, the symptoms and general condition must be closely studied, the discharge must be examined microscopically, the condition of the urine must be determined, and the urethra must be explored.

Exploration of the urethra is inaugurated by inspection and external palpation. Palpation detects induration, peri-urethritis, follicular abscess or inflammation, Cowperitis, etc. The prostate and seminal vesicles are examined by a finger in the rectum. The interior of the urethra is explored with a soft bougie-à-boule (Fig. 713). On withdrawing this instrument the shoulder catches in any contracture. It is to be borne in mind that a large steel sound can often be introduced with ease when the bougie-à-boule makes evident that a contracture exists. The emergence of the instrument is arrested by a patch of thickening, a granular area, a zone of epithelial proliferation,

a papilloma, or a stricture. In fact, anything which lessens the urethral caliber interferes with the withdrawal of the bougie-à-boule. It does not do to conclude that stricture exists simply because some lessening of caliber is appreciated. The bougie-à-boule finds its chief use in exploring the anterior urethra. If introduced into the deep urethra its emergence will be normally checked as its shoulder comes against the posterior layer of the triangular ligament.

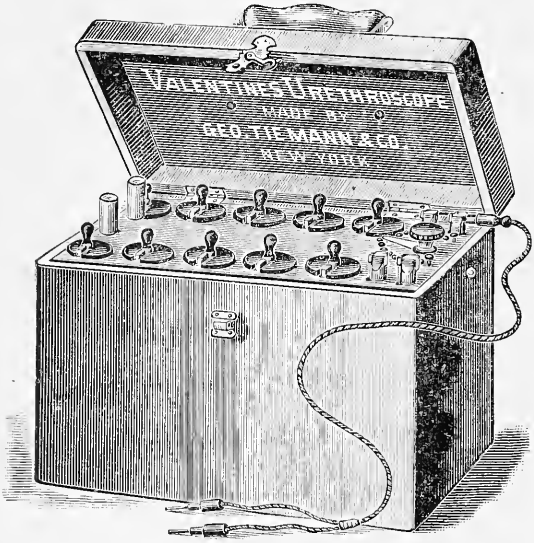


Fig. 714.—Valentine's urethroscope.

In most cases the diagnosis is only certainly determined by the use of the urethroscope. This instrument has been perfected of recent years and is now an absolutely essential part of an armamentarium. I use Valentine's instrument and find it most satisfactory (Figs.

Fig. 715.—Valentine's urethroscopic tube.

714–717). The anterior and posterior urethra can be thoroughly examined with the utmost ease. Before inserting a urethroscopic tube place the patient

Fig. 716.—Valentine's obturator.

recumbent and cleanse the foreskin, glans, and anterior urethra as directed in the section on Cystoscopy. Insert a tube which readily passes the meatus,

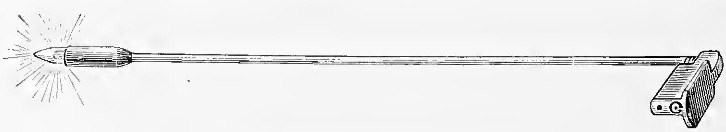


Fig. 717.—Valentine's light carrier.

first cleansing the tube and obturator by burning alcohol upon them. Carry the tube to the anterior layer of the triangular ligament. Withdraw the

obturator and insert the light. Turn on the light, mop the urethra with bits of cotton wrapped on a stick, and slowly withdraw the tube, examining the urethra as its walls fall together back of the retracting tube. After withdrawal of the tube irrigate the anterior urethra. To examine the deep urethra, carry the instrument through the prostatic urethra. After the examination give an intravesical irrigation.

When the cause of a discharge is once determined, rational treatment can be instituted, and to determine the cause the electric urethroscope is indispensable. An erosion of the mucous membrane or a granular patch requires touching from time to time with a solution of silver nitrate (1 or 2 per cent.). These applications are made through the tube of the urethroscope. A

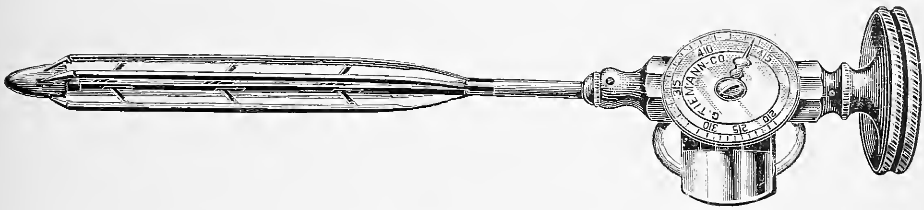


Fig. 718.—Kollmann's anterior dilator.

Fig. 719.—Oberlander's anterior dilator.

Fig. 720.—Kollmann's anteroposterior dilator.

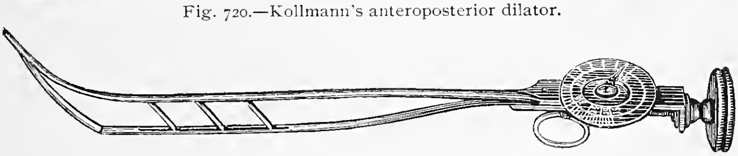


Fig. 721.—Oberlander's anteroposterior dilator.

stricture or an infiltration is treated by gradual dilatation. This combines pressure and massage. If the caliber of the urethra is less than No. 21 of the French scale, conical steel sounds are used twice a week. If there is much hyperesthesia they are retained but a brief time; but as hyperesthesia diminishes the period of retention is lengthened, until an instrument can be kept in place without causing severe suffering for ten or fifteen minutes. It is not desirable to use cocain, as it is distinctly dangerous, obtunds the sensibility so that undue violence may be used, and increases the post-operative inflammation. Before and after using an instrument the urethra must be cleansed as previously directed (page 1155).

When the urethra becomes tolerant to instrumentation, a special dilator

is employed to act particularly on the area of disease. If in the beginning of treatment the caliber of the urethra is equal to or greater than No. 21 of the French scale, it is rarely necessary to precede the dilator by the use of conical sounds. Figs. 718, 719, 720, and 721 show various dilators. Most dilators should be inserted in a sterile rubber cover before being used, otherwise they will cut, tear, or pinch the urethra. Kollmann's dilator will not injure the mucous membrane and can be used without a cover (Fig. 718). A dilator should be lubricated with lubrichondrin or synol soap. If a two-bladed dilator is used at first, a four-bladed dilator must be subsequently employed.

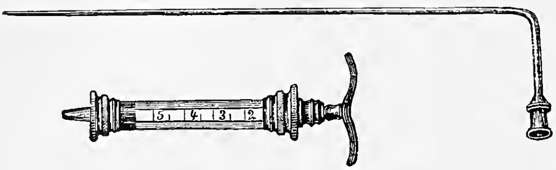


Fig. 722.—Kollmann's gland syringe.

A dilator is cleansed by scrubbing its blades with soap and water, sticking them in alcohol, withdrawing, and burning the alcohol retained in the instrument.

The following rules are of the first importance (Ferd. C. Valentine, in "Med. Record," June 29, 1901):

1. The first dilatation must stop at that point at which the first resistance to further dilatation is felt by the operator's fingers turning the screw that separates the blades.

2. Dilatations, if done by a novice, must in the beginning of treatment be repeated no oftener than every three or four days.

3. Each dilatation, in point of time, must reach no greater duration than two minutes over that of the preceding session.

4. No dilatation must exceed one-half number Chariére above the number attained at the next prior séance, regardless of any lack of resistance that may be present.

As a rule, glandular and follicular infiltrations are cured by the use of the dilator. If they are not, they must be treated through the tube of the urethroscope. The interior of a follicle may be cauterized with an electric wire or subjected to electrolysis, or touched with a 3 per cent. solution of silver nitrate. A thickened crypt, or gland, or follicle, or an area of induration, may be slit with a knife. A polyp can be removed with a snare, the cautery, or special forceps. In a chronic inflammation of the urethra, in which the inflammation is superficial and in which the glands are not involved, irrigations, urethral and intravesical, constitute the best treatment. (See Valentine's treatise on "The Irrigation Treatment of Gonorrhea, its Local Complications and Sequels.")

In any lingering case of gonorrhea examine the urine, and direct suitable treatment for oxaluria, lithemia, or phosphaturia, if any one of these conditions exists. Such morbid states of the urine are occasionally responsible for great prolongation of the inflammation. In some cases a discharge is kept up by inflammation of the seminal vesicles (page 1182).

Gonorrhea of the anus and rectum occasionally, though very rarely, occurs. It may result from pederasty, or in a woman from a flow of infectious material from the genitalia to the anus. It causes severe burning pain, aggravated by defecation. The parts are red, swollen, and tender. The discharge

is profuse, being at first cream white, and then thicker and greenish. The diagnosis rests upon the history and the finding of gonococci in the discharge. The disease rarely extends above the anus.

Treatment.—If the anus only is involved, spray several times daily with peroxid of hydrogen, wash with salt solution, irrigate with permanganate of potash (1 : 4000), dust with talc powder, and interpose a piece of iodoform gauze between the inflamed surfaces. An ulcer, a fissure, or an excoriation is touched with lunar caustic. If the rectum becomes involved, secure a daily bowel movement and irrigate the rectum twice a day with boric-acid solution or permanganate of potash (1 : 4000).

Gonorrhea of the Mouth.—This is a very uncommon malady. It occurs in infants more often than in older people. Infection in infants may take place during birth if the mother has gonorrhea. The symptoms are those of violent stomatitis. The diagnosis is suggested by the condition of the mother and is proved by finding gonococci in the discharges from the mouth.

Treatment.—Wash the mouth frequently with boric acid and listerine (gr. xlviij to ℥viij), and swab the diseased areas at intervals with a 10 per cent. solution of argyrol.

Gonorrhea of the Nose.—It is alleged that this condition can arise, but an absolutely authentic case does not seem to be on record.

Gonorrhea in the Female.—There is much dispute as to the parts infected. Some observers maintain that the vaginal epithelium never contains gonococci and that gonococci found in a vaginal discharge have come from the cervix or uterine canal. Beyond a doubt, however, when young women who have not borne children contract gonorrhea the vulva and vagina usually suffer. In older women and in women who have borne children the vaginal tissues are altered and the cells are not nearly so prone to infection; hence in such subjects the vagina often or usually escapes. The initial infection is in many cases in the cervical canal, in some in the vulva or urethra. No matter what part was first attacked, other parts usually become quickly involved in the acute process. The urethra is involved in almost every case. Chronic gonorrhea is prone to linger in the urethra, in the glands of Bartholin, in the cervical canal, or within the uterus or in the Fallopian tubes. The great danger of gonorrhea in the female is in the development of ascending infection of the lining membrane of the uterus, which may reach the tubes, ovaries, and peritoneum.

When infection occurs during pregnancy or when pregnancy occurs during infection of the cervical or uterine canal, abortion may take place. Again, a pregnant woman may not abort but may go on to term and the child may receive a conjunctival infection during delivery and rapidly develop purulent ophthalmia.

In some cases when pregnancy occurs during the existence of gonorrhea, the disease seems to pass away and yet the child gets conjunctival infection during delivery or the mother subsequently develops pus-tubes.

Treatment.—Place the patient in bed during the acute stage of the disease, give hot hip-baths, keep the bowels open by means of saline purgatives, insist on a fluid diet consisting chiefly of milk, and flush out the urethra by having the patient drink considerable quantities of water. The external genital organs should be sprayed with peroxid of hydrogen every

two or three hours, and after spraying should be dried with absorbent cotton and dusted with equal parts of starch and powdered oxid of zinc, or with powdered stearate of zinc. Pads of cotton fixed in place by a bandage are used to catch the discharge. If urethritis exists in this stage, we may give alkalies, balsams, and astringent urethral injections.

When the acute symptoms have somewhat abated, an attempt should be made to prevent ascending infection from the cervical canal. The mucous membrane of the canal may be cureted away or be destroyed by pure carbolic acid or nitrate of silver. A wiser plan is to paint the cervical canal daily with iodin or a 10 per cent. solution of argyrol, painting the vaginal portion of the cervix at the same time with the same drug. The vagina is irrigated twice a day with a warm solution of permanganate of potash (1 : 4000) and is lightly packed with iodoform gauze. When the vulva is particularly involved, treat that part by applying lead-water and laudanum locally or paint the vulva with silver solution (gr. xl to ℥j). If the vulvo-vaginal gland suppurates, open it.

If vaginitis exists and continues in spite of the treatment suggested above, wash out the vagina every two hours, first with Oj of hot solution of bicarbonate of sodium, next with Oj of hot water, and finally with Oj of astringent solution (a teaspoonful of lead acetate, a teaspoonful of zinc sulphate, a teaspoonful of alum, or four teaspoonfuls of tannin to the pint of hot water) (White). As the attack subsides, use vaginal suppositories, each containing gr. v of tannic acid. In some cases apply solutions of silver nitrate (1 : 200) or of argyrol (10 per cent.), and insert tampons of ichthyol (8 per cent.) moistened with boroglycerid (Le Blonde).

In chronic cases of urethritis use strong solutions of silver nitrate and irrigate the urethra and bladder with silver nitrate (1 : 8000).

For *uterine gonorrhea* observe the same general management. Swab out the uterus with tincture of iodin or nitrate of silver and insert tampons of iodoform gauze.

Gonorrhea in Children.—Male Children.—This disease is not very common. When it affects children under twelve, it is usually due to some abandoned and diseased female having brought the child's penis in contact with her sexual organs. It may result from introducing infected materials into the penis. The symptoms are similar to, but more acute than, those met with in an adult. The finding of the gonococci is clinical but not absolute legal proof of the existence of gonorrhea, and it is to be remembered that boys may suffer from catarrhal urethritis as a result of introducing irritants, from balanoposthitis, or from overacid urine. Legal proof is afforded by the growth of the suspected micro-organisms on artificial blood-serum.

The *treatment* consists of confinement to bed during the acute stage, bland drinks, light diet, etc. Circumcision is necessary if phimosis exists. When the acute symptoms subside, injections are used as in an adult.

Female Children.—Gonorrhea is more common in female children than in male children, and the vagina is involved as well as the vulva and urethra.

A female child may suffer from catarrhal inflammation of the vulva, as a result of the contact of foul urine, of feces, of the presence of seatworms, or of neglect of bathing. In such a case the vagina and urethra escape. Involve-

ment of the vagina and urethra strongly suggests gonorrhea. A recently born child or a young infant may acquire gonorrhea directly from a diseased mother, or indirectly, by pus upon linen, the mother's fingers, etc. A diseased nurse may infect the baby. Older children who have ceased to nurse may get the disease from infected linen, bathtubs, etc., and may by these means infect child after child in an institution. Now and then the disease arises by a diseased man or woman deliberately bringing the child's private parts in contact with their own diseased organ.

The disease is acute: the urethra, vulva, and vagina are usually involved; the discharge is profuse, purulent, and often bloody. During the first day or two the discharge exhibits leukocytes but no gonococci, and the normal flora of the urethra disappear; later gonococci appear (Harmsen, "Zeits. f. Hyg. u. Infektionskr.," 1906, vol. iii). Microscopic examination of the discharge is absolutely necessary. Dry cover-slip preparations are made so as to obtain clap shreds from the discharge. An attempt should be made to obtain cultures. The gonococcus is very difficult to maintain in culture; it must be frequently transferred, and it grows best in an incubator at a temperature of 36° C. No attempt is made to grow it upon ordinary culture-media. The finger may be sterilized and punctured, blood thus obtained being smeared upon ordinary agar. Upon this composite material growth can be obtained. Animal blood serum is not a good medium, but human blood serum is (Lehmann and Neumann). Human blood serum is obtained by opening a vein or from a fresh placenta.

Lehmann and Neumann ("Atlas and Principles of Bacteriology") find the following a satisfactory medium: Agar, containing 1 per cent. peptone and 5 per cent. glycerin, which has been liquefied and cooled to 50° C., is mixed "with one-half its volume of ascites fluid or the fluid from ovarian cysts." Plate cultures and streak cultures should be made. This excessive care in proving the presence of the gonococcus is imperatively necessary in female children because of the medico-legal questions which may arise in such a case and also because of the danger of infecting others.

Surgeons are apt to be doubtful about the diagnosis in many supposed cases of gonorrhea in female children. The clinical picture may simply be that of catarrhal vulvo-vaginitis, it may be that of gonorrhea. The finding of the gonococcus is regarded as conclusive from a clinical standpoint, but not from the legal point of view. Again, as Taylor points out, in some cases in which the clinical and microscopic evidence seems to prove the existence of gonorrhea no proof can be obtained that the condition is of venereal origin, and that in some cases in which everything indicates that the disease began as a catarrhal vulvo-vaginitis, a condition seemingly identical with gonorrhea has arisen. Obtaining a culture of gonococci is conclusive. The treatment consists in taking every care to prevent diffusion of the infection to others and to the patient's own eyes. She is put to bed, given frequent baths, and fed upon milk, etc. Irrigations of bicarbonate of sodium are employed, followed by protargol (1: 5000, according to White and Martin). Later astringent injections are indicated.

Stricture of the urethra, or narrowing of the urethral caliber, is divided into *inflammatory*, *spasmodic*, and *organic*. The so-called *inflammatory* or congestive stricture is not a stricture, but is an inflammatory swelling of the mucous membrane.

Spasmodic stricture does not exist alone, but complicates organic stricture, a hyperesthetic urethra, or an inflamed bladder.

Organic stricture is a fibrous narrowing of the urethra, due, as a rule, to chronic gonorrheal inflammation or to traumatism. True organic stricture is very rare in children, but can occur. Abbe reported a case of impassable stricture in the deep urethra of a male child two and one-half years of age, due to urethral gonorrhea. There were also two strictures of the anterior urethra. External urethrotomy was performed. Traumatic strictures occur in the bulbous or membranous urethra, and are due generally to force applied to the perineum, the urethra being squeezed between the subpubic ligament and the vulnerating body. Strictures resulting from gonorrheal inflammation occur in the penile, bulbous, or membranous urethra. Stricture never forms in the prostatic urethra except as a result of traumatism. Recent non-traumatic strictures are soft and are easily distended. Old strictures and traumatic strictures are very dense. A resilient stricture is one which contracts quickly after dilatation. The nearer a stricture is to the meatus, the more fibrous it is.

A *congenital* stricture is congenital narrowness of a portion of the urethra, usually the portion near the meatus. The more fibrous a stricture is, the more it narrows the urethra and the less dilatable it is. A stricture may be annular (forming a ring around the urethra), tubular (surrounding the urethra for a considerable distance), or bridle (when a band crosses the urethra from wall to wall). A stricture of large caliber will admit an instrument larger than a No. 15 French sound. A stricture of small caliber will not admit a No. 15 French sound. An impermeable stricture will not admit the passage of any instrument. Impermeable is more or less a relative term. A stricture may be impermeable when an anesthetic is not used, and permeable when the patient is anesthetized, or may be impermeable to one surgeon, but permeable to another. Impermeability is often a temporary condition due to inflammatory edema about an organic stricture.

Symptoms and Results of Stricture.—There is usually a history of repeated attacks of urethritis. A chronic discharge may exist, the amount of which is variable. There is a feeling of weight in the perineum, soreness of the back, and frequency of micturition. Hypochondriacal tendencies are usual. In a deep stricture there is difficulty in starting the stream in micturition. In most cases the stream is small, twisted, and forked. There is often interruption or "stammering" of the stream, and it dribbles long after the conclusion of the act, so that the penis must be "milked" before it is returned within the clothing. The urethra back of the stricture dilates, a pouch forms, drops of urine collect and decompose, and a chronic inflammation results in the mucous membrane or the parts adjacent, which inflammation may go on to ulceration or to peri-urethral abscess. A urinary fistula results from the opening externally of a peri-urethral abscess. Retention of urine may occur, not from actual obliteration of the tube by the growth of the stricture, but by closure of the lumen of the urethra by muscular spasm and by edematous swelling in the neighborhood of the stricture. Edematous swelling may be due to cold, wet, venereal excitement, the use of alcohol, overexertion, etc. Spasm of the muscles results, and contact of the urine increases the spasm, and spasm plus edema of the mucous membrane closes

the urethra. Spasm may exist in the urethra itself and in the muscles of the neck of the bladder, but is only a temporary condition. In old strictures the bladder is hypertrophied and often fasciculated, and is very liable to cystitis. The diagnosis of stricture and of its location is made by the use of exploratory bougies. In this examination the author follows to a great extent the plan of Ramon Guitéras, which is as follows: * Have the patient pass urine into two glasses. Examine the urine for clap-shreds. Cloudiness in the first glass shows that urethral discharge exists. Cloudiness in the second glass points to cystitis. The patient is placed recumbent with his shoulders elevated, and the urethra is washed out with warm salt solution or boracic acid. Bulbous sounds are inserted, beginning with No. 15 French. If this passes with ease, take a larger size and note where strictures are situated by the catch on withdrawal. If No. 15 does not pass, use a smaller size. Remember that the posterior layer of the triangular ligament catches a bulbous instrument on withdrawal. If the meatus is too small to permit of exploration, divide it with a curved bistoury, cutting from within outward. After cutting the meatus bleeding is arrested with styptic cotton, and a piece of absorbent cotton is tucked into the cut. After each act of micturition the patient inserts a fresh bit of cotton, and after three days the urethral examination is proceeded with.

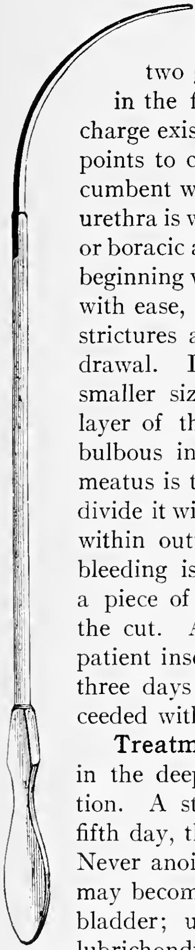


Fig. 723.—Syme's staff.

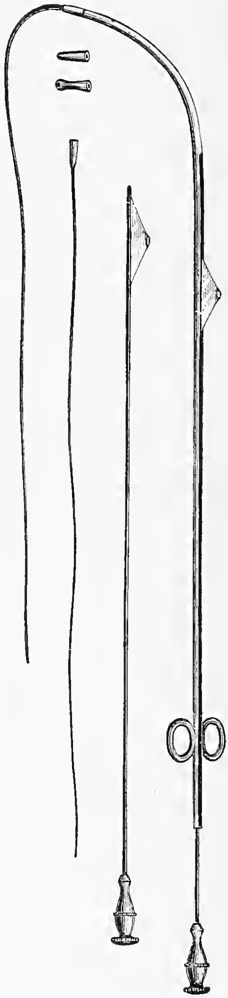


Fig. 724.—Maisonneuve's urethrotome.

Treatment.—A stricture of large caliber in the deep urethra requires gradual dilatation. A steel bougie is introduced every fifth day, the size being gradually increased. Never anoint a bougie with cosmolin, as it may become a nucleus for a stone in the bladder; use oil, glycerin, synol soap, or lubrichondrin. Before passing an instrument the patient urinates and his urethra is washed out with salt solution or boracic acid solution. Glans, meatus, and urethra are cleansed as directed on page 1155. The sound is rendered sterile by boiling before using. Gradual dilatation can be effected by the use of the dilator of Oberlander, the tube being distended to the extent of three millimeters every fifth day. If after dilatation there is urethral spasm, pain, or very frequent micturition, suspend the treatment for a number of days and order each night a hot hip-bath and a dose of pare-

* Med. Record, Nov. 14, 1896.

goric. In effecting gradual dilatation by sounds the instrument should be introduced every fifth day. During the treatment the patient should not use alcohol, should refrain from sexual excitement, should avoid cold and damp, and should take internally capsules containing boric acid and salol. It is rarely necessary to dilate above No. 32 French. After the surgeon finishes treatment he teaches the patient to use an instrument and directs him to pass it once a month. Strictures in the pendulous urethra, if soft, are treated by gradual dilatation; if fibrous and contractile, by internal urethrotomy. In performing internal urethrotomy prepare the patient carefully; for several days before the operation give salol and boric acid by the mouth, and wash out the bladder repeatedly with boric-acid solution. Be thoroughly aseptic. Anesthetize the patient. Before cutting irrigate the urethra with warm normal salt solution, and after cutting irrigate again and tie in a rubber catheter. These precautions will prevent urethral fever. In cutting, insert Gross's urethrotome (Fig. 726) back of the stricture, spring out the blade, cut the stricture on the roof of the urethra, close the blade, withdraw the instrument, and pass a full-sized bougie.

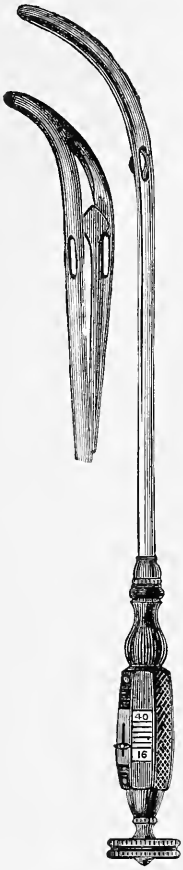


Fig. 725.—Gross's urethral dilator.

Stricture of the meatus requires incision with a knife and the use of a meatus bougie until healing is complete. Strictures of small caliber in front of the membranous urethra require gradual dilatation and, if this fails, internal urethrotomy or divulsion. Internal urethrotomy can be performed with the urethrotome of Maisonneuve (Fig. 724). This instrument is shaped like a sound, has a groove upon its surface, and into this groove a shaft carrying a triangular knife can be inserted. The staff is screwed to a guide, the guide is carried into the bladder and the staff follows it. The point of the staff is carried to the prostatic urethra and the guide curls up in the bladder. The penis is held upon the stretch, the blade is inserted and pushed down through the stricture. This instrument cuts the stricture, but not the healthy urethra. For *divulsion* the patient is prepared as for internal urethrotomy. The divulsor of Gross, or of Sir Henry Thompson, or of Gouley (Figs. 725, 727, 728) is introduced, the blades are separated, the instrument is withdrawn, a large bougie is passed, and a catheter is tied in the bladder. Strictures of small caliber in the deep urethra require gradual dilatation; if this fails, employ external urethrotomy. In strictures of the deep urethra, if only a filiform bougie can be in-

Fig. 726.—S. W. Gross's exploratory urethrotome.

troduced, the bougie may be left in place, and in a day or two another can be slipped in beside it, until in a few days the channel becomes permeable to a metal bougie. A tunnelled catheter can be slipped over the filiform bougie, both be withdrawn, and a metal bougie passed. A tunnelled and grooved staff can be carried in over the bougie and external urethrotomy be performed. Thompson's dilator can be carried in over the filiform and the stricture be divulsed. Fort's method of electrolysis is said to be of value, but I have had no personal experience with it. Fort treats stricture by linear electrolysis. His instrument looks like a whip, and it has a platinum blade projecting from about the center. The blade is connected with the negative pole of a galvanic battery and the positive pole is placed over the pubes. The guide carrying the blade is inserted into the urethra, and when the blade comes against the stricture the current is turned on and the platinum passes rapidly through the constriction. The current is turned off and the instrument is carried onward until it strikes another stricture, when the current is again turned on, and so on. The necessary current-strength is 10 to 15 ma. The operation requires twenty to thirty seconds and causes but little pain. After its performance a sound is passed (a No. 22 of the French scale). The patient need not be confined to bed after this operation. By Fort's method we act purely upon the diseased tissue. In impassable stricture of the deep urethra perform external perineal urethrotomy without a guide (the operation of Wheelhouse).

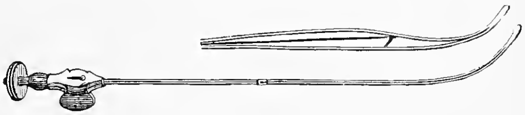


Fig. 727.—Thompson's divulsor.

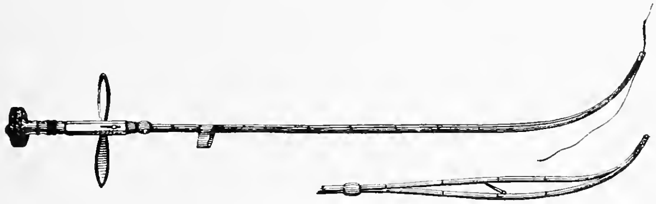


Fig. 728.—Gouley's divulsor.

If a perineal fistula exists, dilate, divulse, or cut the stricture; retain a catheter in the bladder for forty-eight hours. After this period dilate every few days with a metal instrument. Every morning and evening draw the urine with a soft catheter, introduce boric-acid solution into the bladder, remove the catheter, and let the man empty his bladder naturally. A portion will flow from the fistula and a part from the meatus. Day by day the quantity which comes from the fistula lessens, and finally the abnormal opening heals.

Urethral Fever.—Any operation upon the urethra may be followed by a chill owing to shock (urethral shock), and this may be followed by a nervous fever. Urethral fever proper is sapremia following a urethral operation. This condition is due to absorption of toxic elements which

may be in the urine, may have been in the urethra, or may have been introduced from without. It usually follows the first urinary act after operation. It begins with a violent chill and presents the characteristics of a septic fever. It is accompanied by a marked tendency to urinary suppression, and may eventuate in septicemia or pyemia. Urethral fever can be prevented by rigid antisepsis. If this fever should arise, a catheter must be tied in the bladder, the bladder and urethra must be repeatedly irrigated with aseptic or antiseptic fluids, and the patient must be given urinary antiseptics and stimulants by the mouth.

Urinary Fever.—Sir Benjamin Brodie pointed out that the withdrawal of residual urine in a case of enlarged prostate may be followed by very serious symptoms. The condition is spoken of as urinary fever, and is said by many to be due to the sudden and complete emptying of a bladder which has become accustomed to retaining permanently a considerable quantity of urine. Modern studies prove that urinary fever is due to infection of the bladder and kidneys, and not simply to the sudden withdrawal of all of the urine from the bladder, although such a procedure leads to vesical congestion and probably favors infection. The bacteria most often found are pyogenic cocci, colon bacilli, and micro-organisms which cause putrefaction and decomposition of urea.

The condition does not arise promptly, suddenly, and violently, as does urethral fever, but begins rather insidiously after several days. Mr. C. Mansell Moullin thus describes the condition: *

"So far as the broader features are concerned, the symptoms that present themselves in these cases are remarkably uniform. They do not begin at once. Nearly always some few days elapse before there is anything to excite suspicion. Then the urine becomes cloudy, though it may still retain its acid reaction. A small quantity of albumin, more than can be accounted for by the amount of pus that is present, makes its appearance. Under the microscope there are a few hyaline casts, perhaps a blood-corpuscle or two, numerous pus-corpuscles, and myriads of bacteria. The specific gravity is lower than it ought to be, and is lower than it was before the catheter was used. The total amount passed in the twenty-four hours may either increase until it is as much as seven or eight pints, or diminish until it scarcely reaches twenty ounces. There is seldom any definite rigor, but there may be numerous slight chills. The pulse grows more rapid and feeble. The tongue becomes red and dry. There is complete anorexia. Delirium sets in at night, and in a considerable proportion of cases the symptoms rapidly grow worse and worse until, at the end of a few days, the patient sinks into a semi-comatose condition from which he seldom rallies. Post-mortem there are all the signs of recent acute cystitis and pyelonephritis. The mucous membrane lining the pelvis and calices of the kidneys, the ureters, and the bladder is swollen and stained by old and recent hemorrhages, and here and there a thin layer of pus is adherent to it. The pelvis and the ureters are dilated, the apices of the pyramids are eaten away, the cortex is shrunken and hard, the capsule is adherent, and in places between the tubules are minute collections of pus differing in shape and outline according to the anatomical arrangement."

* Lancet, Sept. 10, 1898.

Treatment.—Aseptic catheterization is necessary if we would avoid urinary fever; and as the urethra contains some of the causative organisms, the prepuce, glans, and meatus should be washed with soap and water and irrigated with boric-acid or permanganate of potassium solution, and the urethra be irrigated with boric-acid solution or permanganate of potassium before the sterile catheter is introduced to draw the urine.

If urinary fever arises, it may be possible to control it by frequently irrigating the bladder with warm normal salt solution, solution of nitrate of silver (1 : 8000), or boric-acid solution, and by administering stimulants, diuretics, diaphoretics, saline cathartics, and nutritious food. In severe cases perform suprapubic cystotomy for drainage.

Fig. 729.—Wheelhouse's staff.

Perineal section is external perineal urethrotomy. There are three methods—the operation of Syme, of Wheelhouse, and of Cock.

Syme's Operation.—This operation is employed if a stricture is very contractile, if dilatation fails to cure, or if urethral instrumentation invariably causes pronounced urethral fever. The patient is anesthetized, Syme's staff (Fig. 723) is introduced, and the surgeon makes an incision in the mid-line of the perineum and exposes the staff just above the shoulder of the instrument. The knife is carried along the groove and divides the stricture. A catheter is passed into the bladder from the meatus and is retained for several days, and the wound is dressed antiseptically. After the catheter is removed it must be used every six hours until the urine comes entirely by the meatus. During the rest of the patient's life, a full-sized sound should be passed at regular intervals.

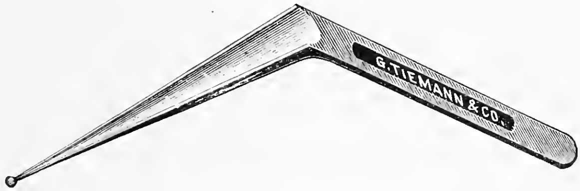


Fig. 730.—Teale's probe gorget.

Wheelhouse's Operation.—This operation is employed for the treatment of impermeable stricture. Wheelhouse's staff is passed into the urethra until it blocks on the stricture. The perineum is incised down to the staff and in front of the stricture. The edges of the cut urethra are held apart with forceps, the surgeon seeks for the opening through the stricture, passes a fine probe through it, divides the stricture, carries into the bladder from the wound an instrument known as a probe gorget to dilate the canal and furnish a solid floor to facilitate the introduction of a catheter. With the gorget in place a metal catheter is carried from the meatus into the bladder. The gorget is removed and the catheter is tied in place. After three or four days the catheter is removed and is then passed frequently. The perineal wound is,

of course, dressed antiseptically. Figs. 729 and 730 show the instruments for Wheelhouse's operation.

Cock's Operation.—This operation opens the urethra back of the stricture and without a guide and relieves retention of urine. The surgeon introduces into the rectum the index-finger of the left hand, and the tip of the finger is rested upon the apex of the prostate gland. The surgeon incises the median line of the perineum, the back of the knife being toward the anus. When the point of the knife is felt to be near the finger the handle is lowered slightly, the blade is placed a little oblique, and the urethra is opened. A catheter is passed into the bladder from the wound and retained for a time, and the stricture is subsequently treated.

Epispadias is a congenital cleft in the corpora cavernosa, the roof of

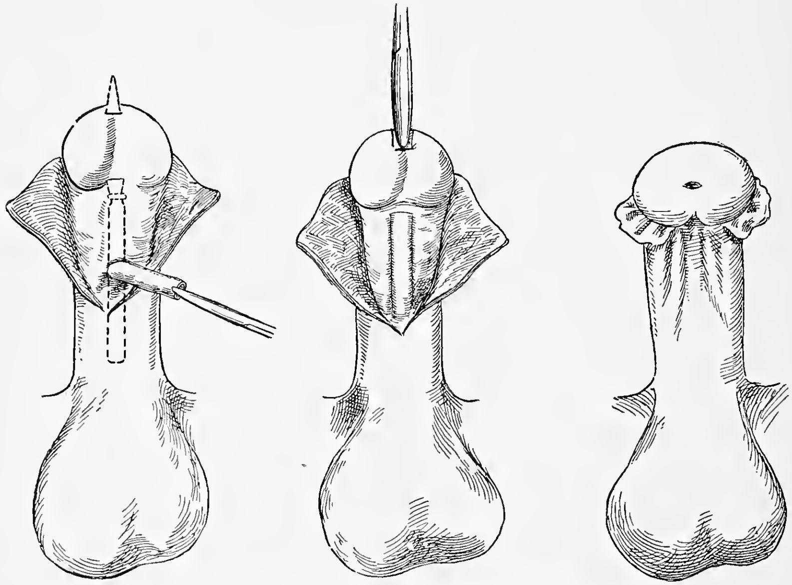


Fig. 731.—Beck's operation for hypospadias.

the urethra being completely or partly absent. In complete epispadias there are absence of the pubic arch and exstrophy of the bladder.

Partial epispadias may sometimes be remedied by a plastic operation.

Hypospadias is a congenital cleft on the floor of the urethra, the meatus opening on the floor at some point between the scrotum and the end of the glans penis, the channel in front of the meatus being a gutter and not a tube.

Hypospadias of the glans is the most common form. In this condition the urethra has no floor, as it passes beneath the glans, the site of the urethra is indicated by a groove, and the foreskin is absent below. Partial hypospadias requires no treatment except possibly dilatation or incision of the meatus. People who suffer from it are very prone to develop chronic urethral inflammation. In hypospadias of the penis the ill-developed cord-like corpus spongiosum draws the penis to the scrotum. In this variety of the deformity the penis is very short.

In complete hypospadias the opening of the urethra is back of the scrotum in the perineum, the penis is dwarfed and bound down, and looks not unlike a clitoris, the scrotum is divided into two portions, a gap existing between them, and in many cases the testicles have not descended. Such individuals are occasionally mistaken for females. In the penile complete forms of hypospadias a plastic operation should be performed between the eighth and tenth years of age. Such an operation unfortunately may fail. Hypospadias is rare in women, but it may occur. In such a case the urethra opens into the vagina. Fig. 731 shows the ingenious operation successfully practised by Carl Beck for penile hypospadias.

Chancroid (soft chancre; the local venereal sore) is an ulcer, usually of venereal origin. The name chancroid was introduced by Clerc, who believed that a soft sore resulted from inoculating a person already syphilitic with the products of a hard sore. He further held that when a soft sore arose the syphilitic poison lost its infective properties, and "could be transmitted as a soft sore to a healthy person, and not cause general infection." * The chancroidal ulcer is not connected with the syphilitic poison, but is developed by inoculation with the bacterium of Ducrey. Until recently it was believed that a chancroid was not produced by a special poison, but arose after inoculation with inflammatory products or irritating secretions. It seems to have been proved, however, by Krefting and Colombini that the organism discovered by Ducrey in 1889 is the real cause. This organism is grown on a medium of fresh blood and bouillon or in "unmixed human blood." (See Lincoln Davis, "Observations on the Distribution and Culture of the Chancroid Bacillus." Report of Research Work, 1902–1903; the Division of Surgery of the Medical School of Harvard University.) As a rule, chancroids are of venereal origin, and result from contact with other chancroids, pus, mucopus, or areas of ulceration. A chancroid appears soon after intercourse, usually within five days, always within ten days. It is first manifested by a pustule which ruptures and discloses an ulcer. This ulcer has sharply defined and undermined margins; it looks "punched out"; the base is gray and sloughy; the discharge is profuse, purulent, foul, and auto-inoculable, and causes fresh chancroids by flowing over the parts. The area around a chancroid is red and inflamed, and considerable pain is apt to be complained of. The original chancroid spreads and new sores appear. The edge of a chancroid is rarely indurated unless caustics have been used or there is mixed infection with syphilis. Inflammatory induration fades gradually into the tissues, but the induration of a hard chancre is sharply defined. Fournier says that a chancroid may have a hard base if the sore is located in the sulcus back of the glans, on a lip of the meatus, or on the lower border of the prepuce of a man with phimosis, or when the ulcer is inflamed. The surgeon should always ask if the sore has been cauterized and how it has been treated. When a chancroid after a time displays marked and sharply outlined induration it points to mixed infection of chancroid and syphilis. Chancroids are not followed by constitutional symptoms, but are apt to be accompanied by painful inflammatory buboes which are prone to suppurate. In hospital practice about 30 per cent. of patients develop buboes. The bubo may be one-sided or bilateral. The adenitis of chancroid

* "Syphilis," by Alfred Cooper.

is due in the majority of cases to the absorption of toxins and pus may be free from bacteria. Cases have been reported in which non-indurated sores were followed by syphilis. It is probable that a mixed infection existed, and that induration was overlooked, because a papular initial lesion was underneath the chancroidal ulcer. When inflammation in chancroids is high, a rapidly destructive ulceration known as *phagedena* may arise (Figs. 732 and 733), but this process is more common in syphilitic sores.

Treatment.—Ordinary cases of chancroid are treated by spraying with peroxid of hydrogen, drying with cotton, touching each sore first with pure carbolic acid and then with pure nitric acid, and dressing with black wash or dusting with iodoform or with calomel. Every few hours the patient soaks the penis in hot salt water (a teaspoonful of salt to a pint of water), sprays the sores with peroxid of hydrogen, dries with cotton, and dresses with black wash or dusts with iodoform or with calomel. As soon as granulation begins the sores should be dressed with 1 part of ointment of nitrate of mer-

Fig. 732.—Buttonhole perforation of the prepuce following phagedenic chancroid (Horwitz).

Fig. 733.—Buttonhole perforation of the prepuce following phagedenic chancroid (Horwitz).

cury to 7 parts of cosmolin. Mild cases do well without cauterizing, peroxid of hydrogen being frequently used and a drying powder being employed. In chancroids with phimosis slit up the foreskin, smear the raw edges of the wound with pure carbolic acid, and treat the ulcers by cauterization. A regular circumcision often fails because of infection of the stitch-holes. Phagedena requires the internal use of iron, quinin, and milk-punch, and the local use of powerful caustics (bromin or nitric acid or even the actual cautery). In some cases continuous antiseptic irrigation is valuable. When a bubo first begins, order rest, apply iodin or an ointment of belladonna or ichthyol, and make pressure by a spica bandage of the groin. Some surgeons advise the injection of 20–40 minims of a solution of carbolic acid (gr. x to the ounce), but I have never seen any benefit from it. Some inject a 1 per cent. solution of bichlorid of mercury, but the proceeding causes intense pain. Welander recommends the injection of a 1 per cent. solution of benzoate of mercury. I have had no experience with this method. If the

bubo persists, even though it does not suppurate, it should be completely excised. If pus forms, several methods of treatment are open to us: aspiration, injection with a solution of carbolic acid, squeezing out the acid and injecting 10 per cent. ointment of iodoform and glycerin, and sealing the opening with collodion (Scott Helms). Hayden makes a puncture, squeezes out the pus, washes out the cavity with peroxid of hydrogen, and then with corrosive sublimate solution, injects warm iodoform ointment, and dresses with cold, moist, corrosive sublimate gauze to set the ointment. Otis, Fontain, Perry, and others commend this plan. We have sometimes found it to succeed. If the above-mentioned plan fails, if it is not used, or if an ulcer or sinus exists, incise, curet, cauterize with pure carbolic acid, cut away hopelessly infiltrated skin, and pack the wound with iodoform gauze. In some cases it will be necessary to extirpate fragments of gland.

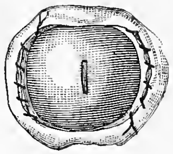


Fig. 734.—Circumcision completed (Esmarch and Kowalzig).

Phimosis is a condition of the prepuce that renders retraction over the glans impossible. It is usually congenital, but it may arise from inflammation. Congenital phimosis causes retention of sebaceous matter, which decomposes and lights up inflammation and the prepuce is apt to grow fast to the glans. Congenital phimosis may induce irritability of the bladder, incontinence of urine, prolapse of the rectum, and various nervous symptoms. The treatment is *circumcision*. Asepticize the parts. Grasp the foreskin and the mucous membrane with two forceps, draw the prepuce forward, catch the skin (at the point it is desired to cut) horizontally between the arms of the handle of a pair of scissors, and cut off the redundant prepuce. Retrench the excess of mucous membrane by cutting around with scissors one-quarter of an inch from the glans, stitch the skin to the mucous membrane with catgut, and dress with sterile gauze (Fig. 734).

Fig. 735.—Cancer of penis (Horwitz).

Fracture of the penis, which is a laceration of the cavernous bodies with extravasation of blood, occurs occasionally during coition. The **treatment** consists of cold and bandaging to arrest bleeding, and occasionally incisions to let out clot.

Gangrene of the penis arises from phagedena, from tying constricting bands around the organ, from fracture with excessive hemorrhage, and from paraphimosis. If extensive, it requires amputation.

Cancer of the penis (Fig. 735) is commonest in persons with phimosis. In a limited epithelioma of the foreskin circumcision is performed and the

glands of the groin are removed; if cancer affects the glans, amputation of the penis and removal of the inguinal glands must be done.

Amputation of the Penis.—Ricord advised cutting off the organ with a single stroke of the knife, making four slits in the mucous membrane of the urethra, and stitching each of these flaps to the skin. Treves splits the skin of the scrotum along the raphé, separates the halves of the scrotum down to the corpus spongiosum, passes a metal catheter down to the triangular ligament, inserts a knife between the corpus spongiosum and the corpora cavernosa, withdraws the catheter, cuts the urethra across, detaches the urethra from the penis back to the triangular ligament, cuts around the root of the penis, divides the suspensory ligament, detaches each crus from the pubes, slits up the corpus spongiosum half an inch, stitches its edges to the rear end of the scrotal incision, introduces a drainage-tube, ligates the vessels, and sutures the wound.

Seminal Vesiculitis.—Inflammation of the seminal vesicles is due to the extension of a gonorrheal inflammation, to a pyogenic process, or to tuberculosis.

Acute inflammation is made evident by frequent and painful micturition, pains in the anus, rectum, and perineum, and possibly the hip-joint, back, and thigh. Defecation and micturition are excessively painful. Persistent erections may take place, and in some cases bloody ejaculations occur. Rectal examination detects the enlarged and tender vesicles external to the lateral lobes of the prostate and on a higher level.

Treatment.—Abandon local urethral treatment, and treat the patient as for acute prostatitis.

Chronic vesiculitis may result from the acute form or may develop insidiously in an individual with gonorrhea. It is one of the causes of chronic urethral discharge. The patient suffers from imperative and frequent demands to micturate, and he has a gleety discharge which becomes worse and better, but does not disappear. This chronic inflammation is believed to persist because of narrowing of the duct and consequent incomplete drainage of the vesicle. In chronic seminal vesiculitis there is usually sexual weakness, nocturnal emissions occur, and the semen may contain blood.

Treatment.—Treat the posterior urethritis by ordinary methods. Use hot rectal enemata. Milk the ducts by Fuller's method once every seven days. During massage the patient's bladder should be full. He leans over a chair-back, the knees being straight and the body at a right angle to the thighs. The surgeon covers his finger with a rubber stall and anoints it with oil or synol soap, and introduces it into the rectum, and makes pressure over the pubes with the fist of the other hand. The finger comes in contact with the lower half of the vesicle; it makes firm pressure for a moment, and is then drawn slowly toward the duct. This stroking is repeated several times. The other vesicle is treated in the same manner. This maneuver empties the vesicle and hastens the resolution of inflammation. After the completion of the stripping the patient should micturate, and the bladder and urethra should be irrigated.

Tuberculosis of the Seminal Vesicles.—Primary tuberculosis is very unusual. As a rule, there is antecedent tuberculosis of the testicle or prostate gland. About 50 per cent. of the cases occur in individuals under

forty years of age. The diseased vesicle is at first nodular and indurated, but later undergoes caseation and softening. Finally the disease passes through the capsule and invades adjacent structures. Dreyer collected 36 cases and found that in 34 of them the lungs were involved.

Tuberculous vesiculitis may be unilateral or bilateral. In unilateral tuberculous epididymitis the corresponding vesicle is apt to become diseased. In bilateral disease of the testicles both vesicles are liable to involvement. Peritoneal tuberculosis may follow tuberculous vesiculitis. In very unusual cases spontaneous cure is obtained by fibrous-tissue formation. On palpation a tuberculous vesicle is found to contain here and there hard and but slightly tender nodules.

Treatment.—If tuberculous epididymitis is followed by tuberculous vesiculitis, it is justifiable to remove the vesicle after removing the testicle, provided the prostate and other parts of the genito-urinary tract are free from disease and there is no distant lesion of tuberculosis. If both testicles are removed, both vesicles can be extirpated. If a vesicle or both vesicles suffer from primary tuberculosis, operation is advised by some surgeons. Reported cases, however, do not seem to favor operation.

Kraske, Schede, and Rydygier have removed the vesicles after preliminary resection of the sacrum. Zuckerkandl, Dittel, and Schede have employed the perineal route. Villeneuve reached them by way of the inguinal region. The curved perineal incision of Zuckerkandl is the method usually preferred. H. H. Young makes a suprapubic incision, strips the peritoneum from the bladder, and reaches the vesicles from behind. He calls it the suprapubic-retrocystic-extraperitoneal method (H. H. Young, in "Annals of Surgery," Nov., 1901).

Acute Prostatitis.—Acute inflammation of the prostate gland may be caused by inflammation in adjacent structures, the use of instruments or irritant applications in the deep urethra, injury by a passing or impacted calculus, various infectious diseases, a stricture of the urethra, but particularly by gonorrhea. The gland enlarges greatly, the prostatic fluid exudes mixed with blood and pus, and the gland-ducts become distended with pus. A distinct abscess may form. The orifices of the ejaculatory ducts become distended and filled with pus, and the seminal vesicles or epididymis may also suffer. An abscess is liable to form in the cellular tissue outside of the prostate.

Symptoms.—A feeling of weight, fulness, or soreness in the perineum; a persistent pain at the neck of the bladder; frequent micturition, pain being present and becoming most severe as the last drops are voided; perineal tenderness; painful defecation; and bulging of anal mucous membrane. If a finger is introduced into the rectum, it causes severe pain and palpates the enlarged and tender gland, unless the outlines are destroyed by periprostatitis, in which case there will be felt a large, boggy, tender mass. (See Henry Morris on "Injuries and Diseases of the Genital and Urinary Organs.") These symptoms are accompanied by distinct elevation of temperature. The inflammation may abate without suppuration, but, as a rule, pus forms, the temperature becomes characteristic, the pain becomes pulsatile, micturition causes agony, the inflammatory mass is felt per rectum to be softening, and sometimes the swollen perineum becomes dusky red. Retention of urine is almost

certain to occur. The abscess may rupture into the urethra or the rectum, or may diffuse in the periprostatic cellular tissue and subsequently may open in the perineum. Spontaneous evacuation may be followed by recovery or by the development of annoying or dangerous complications.

Treatment.—Keep a hot-water bag on the perineum and three or four times a day use rectal injections of hot water. Place the patient on a milk-diet. Leech the perineum. Give suppositories of opium and belladonna, and also suppositories of ichthyol, and administer urotropin by the mouth. At the first sign of suppuration make a curved perineal incision. Retention of urine is relieved by a soft catheter.

Chronic Prostatitis.—May arise from stricture, venereal excess, chronic cystitis, or stone in the bladder, but gonorrhea is the common cause. The prostate is usually, but not always, enlarged, is somewhat softened, and the ducts contain pus and blood.

Symptoms.—There is usually a mucopurulent discharge or fluid can be obtained by massage of the prostate. There is a feeling of weight and fulness in the perineum, there is increased frequency of micturition, and the prostate is very sensitive to digital pressure. The patients are neurotic, frequently suffer from nocturnal emissions, and have but feeble power of erection. The prostatic urethra is extremely hyperesthetic. All the symptoms are aggravated by worry, sexual excitement, or violent exercise. An abscess may form and rupture into the urethra.

Treatment.—Tonics and nutritious food are essential. Intravesical irrigations with nitrate of silver solution (1 : 8000) do good. Massage of the prostate is useful. Some cases are benefited by touching the posterior urethra through a urethroscope tube with nitrate of silver (3 grains to the ounce) or by injecting by means of Ultzman's syringe a few drops of silver nitrate solution (5 grains to the ounce). Rectal suppositories of ichthyol may be ordered. Blistering the perineum at intervals may prove of service. At intervals of three or four days a full-sized cold steel sound should be gently introduced. If an abscess forms, open it through the perineum.

Prostatorrhea.—Just as overaction of the glands of the urethra constitutes urethrorrhea, so overaction of the glandular apparatus of the prostate gland constitutes prostatorrhea. Prostatorrhea is not inflammatory, although the prostate and posterior urethra are often congested, and the latter region is usually hyperesthetic. In some cases urethrorrhea exists with prostatorrhea. Prostatorrhea is produced by sexual excess, masturbation, ungratified sexual desire, and riding a bicycle with an improper seat. The condition is usually accompanied by marked neurasthenia, and may be associated with spermatorrhea and impotence.

The patient notices a milky or gray discharge after straining at stool (*defecation-spermatorrhea*), after violent exercise, sexual excitement, or a bicycle ride. The discharge also gathers in the urethra during sleep. Examination of the discharge shows it to be prostatic fluid, although spermatozoids are sometimes found. It is not purulent and contains amyloid corpuscles. The meatus is not glued up in the morning, and the linen is very slightly stained. The urine is clear and contains small comma-shaped hooks (Christian). Sexual excitement and alcohol do not appreciably aggravate the condition. The bladder is irritable, and there are frequency of micturition and

often some pain in the head of the penis at the termination of the act. Nocturnal emissions may occur.

Treatment.—The patient should correct bad habits. If there is urethral hyperesthesia or prostatic congestion, irrigate the bladder and urethra once a day with a solution of silver nitrate (1 : 4000), and every fourth or fifth day introduce a cold sound. In some cases the occasional instillation into the prostatic urethra of a few drops of a 1 per cent. solution of nitrate of silver does good.

For the irritable bladder give hot hip-baths at night. The following prescription is of service: gr. xv of bromid of potassium, ½ dram of tincture of hyoscyamus in ½ ounce of cinnamon-water, three times a day. Hot enemata are of service.

After the hyperesthesia of the urethra has abated and nocturnal emissions have ceased, the neurasthenia is treated by cold sponging of the body night and morning, the continued use, at intervals of several days, of a large-sized cold sound, irrigation every second or third day with silver nitrate (1 : 4000), and the administration of strychnin and other tonics.

Hypertrophy of the Prostate Gland.—It was pointed out by Morgagni that in old men difficulty of micturition is due to obstruction by an enlarged prostate gland. Enlargement of the prostate gland may be brought about by different forms of growth. It is, as a general thing, a senile change, occurring only after the age of fifty, and being most likely to arise after the attainment of sixty years. It is very rare for enlargement of the prostate to cause symptoms long before the age of fifty or to begin after the age of seventy. Sir Henry Thompson maintained that 34 per cent. of men over sixty have prostatic hypertrophy, but that only half of them have troublesome symptoms. According to Freyer, 33 per cent. of all men past fifty-five years of age present some enlargement of the prostate.

There are some that oppose the view that prostatic enlargement is essentially a senile change. For instance, Dr. L. Bolton Bangs ("Jour. of Dermatol. and Gen.-urin. Dis.," March, 1901) maintains that the change is not senile; that it really begins early in life, but that its effects do not become manifest until during or after middle age. Lydston asserts that it begins during the third decade of life, but does not attain sufficient size to cause symptoms till beyond middle life. Socin and Burckhardt, as a result of 300 postmortem examinations, reached the following conclusions: Between the ages of thirty-six and forty the gland is hypertrophied in 13 per cent. of cases, between forty and fifty in 25 per cent., between fifty and sixty in 31 per cent., between sixty and seventy in 56 per cent., between seventy and eighty in 50 per cent., between eighty and ninety in 54 per cent. Undoubtedly, the enlargement begins long before it occasions sufficient obstruction to induce symptoms, and the growth progresses very slowly. Guyon and the French school maintain that hypertrophy of the prostate gland is always the result of arteriosclerosis, affecting not only the prostate, but also the entire urinary tract. The hypertrophy that ensues affects the bladder-walls notably, as well as the prostate, because of distinct growth. Caspar has apparently demonstrated that Guyon's view is not correct. He has shown that in many cases there is no sclerosis of the prostatic arteries, and that frequently there are no sclerotic changes in other portions of the urinary tract. Another

important point made by Caspar is that arteriosclerosis tends to cause degeneration, and not hypertrophy.

Some think sexual excess is a cause of prostatic enlargement; some think antecedent gonorrhea is the cause, but this seems very improbable; Belfield blames altered testicular secretion; Hawley believes the cause to be altered prostatic secretion and the "chemical action of pathologic proteids resulting from irregular metabolism or derived from disintegration of the secretion, or in the usual action of tissue enzymes" (G. W. Hawley, in "Annals of Surgery," Nov., 1903).

In the hypertrophied prostate there is an excessive production of fibrous tissue and of ill-formed glandular tissue, the mass constituting a fibro-adenoma. Fibro-adenoma is the common cause of enlargement (W. Bruce Clarke). Typical adenoma, according to Albarran and Hallé, is found in 14 per cent. of the cases ("Ann. des Mal. des Org. Gén.-Urin.," Feb. and March, 1900). Again, in not a few prostates there is no real enlargement, but there is an indurated fibrous mass producing obstruction. Albarran and Hallé ("Annales des Maladies des Organes Génito-Urinaires," 1898, vol. xvi) point out that in an enlargement of the prostate different elements may usually be recognized: soft hypertrophy of the gland; indurated enlargement of the glandular elements; fibrous enlargement; circumscribed tumor-masses; distinct fibromata or myomata; or adenofibromyomata. The real cause of the various forms of prostatic enlargement is not known. Nearly 10 per cent. of cases are cancerous (Oraison), and adenoma is apt to be transformed into cancer.

All the lobes may be enlarged equally; all may be enlarged unequally; the enlarged gland may surround the prostatic urethra like a horse-collar; or one lobe only may be enlarged. Symmetrical enlargement of the entire gland is not so apt to produce symptoms as is a non-symmetrical enlargement. In some cases the chief enlargement is into the bladder; in others, into the urethra. An enlarged prostate frequently shows a circular groove about it, due to the constriction exerted by the rectovesical fascia at the vesical neck.

The bridge of prostate which joins the two lateral lobes behind the urethra is known as the *lobe of Home* or the "*middle lobe*," and a comparatively trivial enlargement of the middle lobe may cause obstruction. Prostatic hypertrophy causes a narrowing and lengthening of the urethra, and gives this tube a tortuous course. The opening of the urethra into the bladder is usually pushed to a higher level, and there forms behind it a pouch in which urine collects. The urine that gathers in this pouch is known as *residual urine.* It cannot be voluntarily expelled. It may, therefore, collect in large quantity, and it is likely to decompose, producing cystitis. Residual urine strongly favors calculus formation. The mechanical resistance to the expelling of the urine causes congestion of the neck of the bladder and the posterior urethra and also hypertrophy of the muscles of the bladder. In consequence of the hypertrophy the bladder enlarges, thickens, and becomes fasciculated. When this takes place, micturition becomes very difficult and sometimes impossible. Enlargement of the middle lobe inevitably blocks the flow of urine and causes great distention of the bladder. In hypertrophy of the prostate gland the ureters and the renal pelves and calyces may distend and surgical kidney may develop.

It is useful to divide, as does Horwitz, persons with prostatic hypertrophy into three groups: (1) those in whom there is no obstruction or in whom the urinary symptoms are very trivial; (2) those in whom there are residual urine and disturbances of urinary function, who depend upon the catheter for relief, but who do very well by this method; and (3) those that suffer a complete breakdown during the period in which the catheter is depended upon (Orville Horwitz, in "Phila. Med. Jour.," Nov. 16, 1901).

Symptoms.—In 90 per cent. of the cases there is very trivial inconvenience, the patient merely being annoyed somewhat by episodes of nocturnal frequency of micturition. The stream of urine is slow to start and falls feebly from the end of the penis. In some cases there is interruption of the stream (stammering). The last drops fall entirely without control. If the patient becomes chilled or worried, or indulges inordinately in the pleasures of the table or in wine, beer, or alcoholic liquors, nocturnal frequency of micturition becomes for a short time most harassing. In 10 per cent. of all cases the bladder cannot be emptied entirely, and residual urine collects. Frequency of micturition comes on, particularly at night; the patient has to get up often; the bladder never feels empty; and cystitis is apt to arise. The urine, at first acid and clear, becomes neutral and cloudy, and finally ammoniacal and turbid, and contains bacteria, mucopus, precipitates of phosphates, and blood. Above the pubes there is aching pain, soon spreading to the perineum, which pain is increased when the bladder is distended and during micturition. The rectum becomes irritable, and piles form or prolapse of the mucous membrane occurs, because of straining in micturition. Attacks of retention of urine may occur. In about one-third of all cases we can make a diagnosis by rectal palpation. In enlargement of the middle lobe alone or in pure intravesical enlargement rectal touch will fail to make the diagnosis and the cystoscope must be relied upon. The bladder becomes thin and distended, or hypertrophied, rigid, and fasciculated. In rare cases true incontinence is caused by the median lobe growing toward the neck of the bladder and preventing closure. The health breaks down because of pain, restless nights, indigestion, and disorder of the bowels. The kidneys may become involved (inflammation of the pelves or calyces, or surgical kidney), and suppression may occur. Septic fever may arise. Calculi may form in the bladder. Death is due to exhaustion, suppression of urine, or septic cystitis. A foul catheter is the usual cause of septic cystitis, but micro-organisms sometimes enter by passing along the urethral mucous membrane.

A patient should be examined by rectal touch, by a sound, and by a cystoscope, if possible; the amount of residual urine must be determined, and the condition of the urine is carefully studied. The presence or absence of stone should always be determined. After an examination by instruments the patient must remain in bed for twenty-four hours.

Treatment.—There is no known method of preventing prostatic hypertrophy. Many cases of enlargement are treated by regular catheterization, and if this is conducted with careful cleanliness, if the patient rigidly adheres to hygienic rules, he may be kept comfortable for a considerable time. Alexander has formulated several sound rules as to when catheterization is the proper treatment. He says, if the patient is intelligent and dextrous, if cystitis is not severe, if the amount of residual urine is not very large, if obstruction is not

great, if the bladder retains considerable expulsive power, and if catheterization is easy and painless, we are justified in relying upon this simple plan of treatment. Prevent cystitis by emptying the bladder each evening with a coudé catheter. If there is trouble in passing the catheter, strengthen the instrument by inserting a filiform bougie as a stylet (Brinton). It is very seldom that a metal instrument is used, but if it is required, a catheter with a large curve is employed. If a soft semisolid instrument can be passed, teach the patient how to clean it, how to use it, and how to keep it, but never permit the patient to use a metal instrument himself. A dirty instrument may cause fatal infection. It is true that some people use dirty instruments for long periods without trouble, but in most cases there will be trouble if it is attempted. It is absolutely necessary to use only perfectly aseptic instruments. Metal instruments are sterilized by boiling in water. Rubber catheters can be cleansed by washing with soap and running water and boiling. Woven instruments can be placed in a glass cylinder, the bottom of which is like a sieve. This jar is placed for twenty-four hours in a vessel which contains formalin. The vapor of formalin is an excellent germicide, and does not injure the catheter. After sterilization the instruments are kept ready for use in a glass cylinder which contains calcium chlorid.* Guyon scrubs the catheters with soap and water, dries them outside and inside, and places them in a sealed jar, and exposes them to the vapor of sulphurous acid for forty-eight hours. If there are three ounces of residual urine, use the catheter only at night. If there are six ounces, use it night and morning. If there are more than six ounces of residual urine, add one more catheterization a day for every additional two ounces present until the catheter is used six times in the twenty-four hours. It should never be used oftener than this. Gradual dilatation with steel sounds is of benefit, but forcible dilatation is not advisable. The sound may be passed once a week. Tell the patient to avoid violent exercise, cold, damp, sexual excitement, and the use of alcoholic liquors; prevent constipation and indigestion, and direct him to drink milk and plenty of water. A hot hip-bath at night adds to his comfort. Hot enemata are of value. If a large quantity of residual urine exists, or if cystitis begins, wash out the bladder daily with boric-acid solution, or normal salt solution, or nitrate of silver (from 1 : 10,000 to 1 : 2000), and give urotropin or salol and boric acid by the mouth (Cystitis, page 1137). In some severe cases, if a large-sized rubber catheter be tied in the bladder for a few days, great relief is obtained. Retention of urine can be relieved by the introduction of a coudé catheter strengthened with a whalebone. In exceptional cases a silver instrument with a prostatic curve must be employed or aspiration must be practised. Many cases occurring among well-to-do people can be kept comfortable by catheterization. Some surgeons still think that only when this fails should an operation be performed. Unfortunately, sooner or later the regular use of the catheter will cause cystitis. A poor man cannot give the necessary time and attention to make catheter life safe and operation must be thought of in him sooner than in others. If the symptoms grow constantly worse, if the suffering becomes severe, if the patient cannot urinate without the use of an instrument, if catheterization is painful or impossible, if the patient is too careless or ignorant to trust with a catheter, if only a catheter of very

* R. W. Frank, in Berliner klin. Woch., No. 44, 1895.

small size can be introduced, if attacks of obstinate retention occur, if there is persistent or recurring cystitis or hematuria, if there are signs of beginning infection of the kidney, if the residual urine gradually increases in amount, the bladder should be opened. Do not postpone operation until the patient becomes really ill. Give palliative measures a reasonable trial, and if they fail, operate. Before determining upon any operation make a cystoscopic examination. This is particularly valuable before a Bottini operation and before a perineal operation. It shows us the condition of the bladder; the nature, size, and situation of the enlargement, the median lobe if present, and a calculus if one exists. This examination may determine the form of operation desirable. Prostatectomy is not to be regarded as a trivial affair certain to result in cure. It is a grave procedure, with a considerable mortality, which may be attended by disastrous complications and from which unfortunate consequences may arise. I agree with James E. Moore that—"It is altogether too grave an operation to be resorted to as a routine treatment for every enlarged prostate, and is applicable only to properly selected cases." The operation is contraindicated if there is advanced disease of the kidneys, and if it is performed in such a case, fatal uremia is to be expected. Age is not in itself a contraindication if the kidneys and cardiovascular system are sound. An occasional sequel of prostatectomy is incontinence of urine due to injury of the neck of the bladder or to the nerves of the part. A usual sequel is impotence.

In the majority of cases in which palliation fails the operative indication is to remove an obstructing mass and depress the level of the opening from the bladder into the prostatic urethra, so that the prostatic pouch is abolished and the bladder can be thoroughly drained. It was formerly believed that any operation of total prostatectomy must of necessity produce impotence. This we now know need not be the case. The suprapubic operation is probably less likely to be followed by this than is the perineal, as it usually spares the ejaculatory ducts. Young's perineal operation, it is claimed, spares the ejaculatory ducts. Destruction of the ejaculatory ducts certainly produces sterility and may produce impotence. Willy Meyer ("Med. Record," Oct. 7, 1905) points out that impotence may also be caused by damaging important nerves or blood-vessels in advancing through the perineum, and also by the operation producing relaxation of the verumontanum and prostatic urethra, parts necessary in the reflex for erection.

The perineal operation is as safe as the suprapubic, or safer, and can be rapidly performed. It is the desirable route when the gland can be palpated per rectum and does not mount high up when we are dealing with the early stages of soft hypertrophy (Willy Meyer, in "Med. Record," Oct. 7, 1905), and when prolonged drainage is required. According to Francis S. Watson ("Annals of Surgery," June, 1904), the mortality in 203 cases was only 2.9 per cent.

After the performance of the perineal operation the drainage is at the lowest part of the bladder. In a perineal operation every effort should be made to do as little damage as possible to the urethra. If we destroy the entire prostatic urethra, the operation becomes easy and rapid and nature rapidly repairs it, but a traumatic stricture may follow and may make the patient's condition worse than at first. As Moore says, we must destroy a portion of the

floor of the urethra, but we can preserve the roof and the side walls. Another point in the perineal operation is to avoid injuring the rectum. A tear may enter the rectum, or, even if the gut was not torn, sloughing of the rectum resulting in recto-urethral fistula may occur. The rectum may be opened because the surgeon fails to stick close to the urethra in his dissection, and sloughing may be due to an injudicious use of the retractors. If the rectum is opened, it should be at once sutured with catgut. In most cases it takes about three weeks for the wound in the perineum to heal, and in some few cases a perineal urinary fistula is established. Urinary incontinence may follow this operation. By simply incising the prostate gland the floor of the urethra may be lowered to the level of the floor of the bladder (Dandridge). Simple incision of the prostate in this manner is known as *prostatotomy*. The mortality is small and the relief is often great. Prostatotomy is performed on old and exhausted patients with damaged kidneys. A large tube should be worn during the healing of the wound.

The suprapubic operation is easier than the perineal; it is less safe, it gives excellent results if temporary drainage only is needed. According to Watson ("Annals of Surgery," June, 1904), the mortality in 69 cases was 8.6 per cent. It is indicated in rather young subjects in whom we greatly fear impotence; in cases in which the gland is placed high; in cases in which the gland is not palpable per rectum but is causing serious symptoms, and in which the hypertrophy is recognized by the cystoscope (Meyer), this condition exists if there is a middle lobe; in cases in which cancer exists; or in which calculus complicates the case. It is the most useful operation when the hypertrophy is very large and intravesical. It is not a suitable method if the bladder is markedly contracted or if the belly-walls are very thick. If prolonged drainage is required, as it is sure to be in cases with advanced cystitis, the opening is better placed in the perineal operation. If when a suprapubic operation has been performed it is found that prolonged drainage is indicated, a siphon drain (Fig. 700) is used. If permanent drainage is required in a case, the suprapubic method is the best. After a suprapubic cystotomy has been performed for drainage, the opening may be kept permanently patent by the retention of a tube (Hunter McGuire's operation). It is only in very advanced cases or in cancer that permanent suprapubic drainage is employed. After making a suprapubic incision the floor of the urethra cannot be brought level with the floor of the bladder by a simple incision of the prostate through this incision; it can be brought level only by the performance of prostatectomy. Suprapubic prostatectomy inflicts injury upon the bladder, it may gravely damage the sphincter of the bladder, and is often followed by inability to expel urine (John B. Murphy, "Jour. Amer. Med. Assoc.," March 29, 1902). The bladder-wall may be seriously torn, and if such a wound should be inflicted, it ought to be sutured with catgut. In this operation, if the bladder is contracted, the surgeon must exercise great care to avoid injuring the peritoneum. The ureters may be damaged and subsequently become obstructed from contraction.

Suprapubic Prostatectomy.—After the bladder is opened the mass of prostate is enucleated or cut away with scissors or with cutting forceps. The bladder is drained for a time and the suprapubic cut is then allowed to heal. If the suprapubic method of prostatectomy is employed, it is often wise to

use also a perineal cut, in order to control hemorrhage and secure good drainage. Freyer has had remarkable success with suprapubic enucleation. He states that he does not destroy the prostatic urethra, and that if obstruction is entirely removed, there is a return of the power of voluntary micturition.

McGill's Operation: The bladder is opened by a suprapubic incision, the edges of the cut bladder are sutured to the abdominal wound with catgut, and the interior of the viscus is carefully explored with the finger and by sight, an electric light being used for illumination. If a sessile growth exists, the mucous membrane is incised and the growth enucleated with finger or a curet. A pedunculated growth is cut away with sharp-edged forceps. If a mass projects into the bladder, an incision is made to divide it into two portions and each half is enucleated. Hemorrhage is arrested by irrigation with hot salt solution and by compression with gauze pads. In some cases a tampon must be inserted. The bladder is drained for several days or a number of days by a siphon (Fig. 700). As a matter of fact, a dense fibrous prostate cannot be enucleated and can be removed only by scissors or cutting forceps.

Fuller's Operation: Open the bladder above the pubes; have an assistant push the gland up by means of a fist in the perineum. The gland can be lifted by two fingers in the rectum (Guitéras). The surgeon makes a small incision through the mucous membrane over the prostate, enucleates the gland by means of the finger, and drains through an incision in the membranous urethra, as well as through the suprapubic opening.

Belfield's Operation: Belfield performs suprapubic cystotomy, makes a perineal cut to enable the finger to approach the prostate, pushes the prostate up toward the belly, and enucleates it from within the bladder.

Perineal Prostatectomy.—Perineal prostatectomy is less bloody than suprapubic prostatectomy. The sphincter of the bladder is not damaged, the entire prostate can be brought into view and removed, and perfect drainage is obtainable after operation.

Nicoll's Operation: Perform suprapubic cystotomy. Then incise the perineum down to the prostate, split the capsule of the prostate, insert two fingers of the left hand into the bladder, and push the prostate into the perineum so as to bring it within reach. Enucleate the gland from the perineal wound without damaging the mucous membrane of the floor of the bladder.

Alexander's Operation: Alexander makes a suprapubic incision and uses it for the same purpose as does Nicoll, but he also opens the membranous urethra on a grooved staff. After enucleating the gland he inserts a drainage-tube through the incision in the membranous urethra. In a very thin subject it may not be necessary to perform suprapubic cystotomy. Alexander has brought the gland into an accessible position in the perineal wound by suprapubic pressure, and Guitéras has done so by making an incision in the linea alba and inserting two fingers into the prevesical space. Syms advocates opening into the peritoneal cavity, inserting the hand, and pressing the prostate into the perineum without opening the bladder above the pubes.

Bryson's Operation: This is a very satisfactory method. The bladder is irrigated and filled with warm salt solution. A grooved staff is intro-

duced and a median perineal section is made to open the urethra just in front of the apex of the prostate gland. The knife is pushed back in the groove of the staff sufficiently far to incise the ring at the apex of the prostate; the forefinger is passed into the prostatic urethra and the staff is withdrawn. Then a short tear is made by means of a blunt instrument into the mass of the left lobe and the finger is introduced and enucleates the lobe. The same procedure is carried out on the right lobe, and, finally, if necessary, on the middle lobe. If the middle lobe requires removal, but cannot be reached, a suprapubic cut is made into the cave of Retzius, two fingers are inserted, and the lobe is pushed within reach of the finger below. A large perineal tube is introduced for drainage and bleeding is arrested by packing. Horwitz also introduces a catheter and ties it in place.

Young's Operation: This surgeon frequently operates under spinal anesthesia. He places the patient in an exaggerated lithotomy position and introduces a sound. In thin subjects the incision is in the raphé and is carried close to the anus; in short individuals the incision is an inverted V. He incises the recto-urethralis muscle transversely, exposes the membranous urethra, opens it, and inserts his tractor into the opening in the urethra (Fig. 740). The tractor is turned 180°, the blades are opened, and traction is made. The capsule is incised on each side of the ejaculatory ducts and the gland is removed by blunt dissection, the forceps grasping each lobe during enucleation (Fig. 741). Every effort is made to save the urethra. After removing the lateral lobes the tractor is used to bring a middle lobe, if one exists, into the wound, and it is also enucleated. The bladder is drained for about one week.

Bottini's Galvanocaustic Prostatotomy.—Bottini, of Padua, in 1874 suggested cauterizing the prostate by means of a special instrument. He sought to burn away a portion of the gland in hope that the contraction of the scar would cause the remainder of the gland to shrink. The instrument of Bottini is shaped like a catheter, and carries a platinum blade which is heated by an electric current. Bottini's early instrument was not satisfactory and the operation never became popular until Freudenberg improved the tools in 1897 (Fig. 736).

Bottini's galvanocaustic operation is performed as follows: The bladder should be emptied, irrigated, and distended with air, and the posterior urethra must be anesthetized by instillation of cocain or eucain. The current is tried to see how many seconds it requires to heat the blade sufficiently. The current is broken, the instrument is introduced, the cooling current is set in motion, and one assistant watches this and nothing else. Turn on the current. Wait the required number of seconds for the blade to become red hot (twelve to fifteen seconds), turn the screw at the handle, and burn a groove in the prostate. A groove should be burned toward the rectum, one to the side, and, if it is thought desirable, one to the opposite side. No groove should be burned toward the pubes. When a groove has been burned, return the blade into its sheath, increasing the current while doing so in order to keep the blade from adhering to the tissue, then shut off the current. After withdrawing the instrument it is not necessary to introduce and retain a catheter. The patient is confined to bed only twenty-four hours, there is rarely bleeding or fever, and the results are good. The scars contract and the gland atrophies. During the period of healing a steel sound should be passed from time to

time (Bangs). It is alleged that fibrous stricture of the neck of the bladder may follow in some cases.*

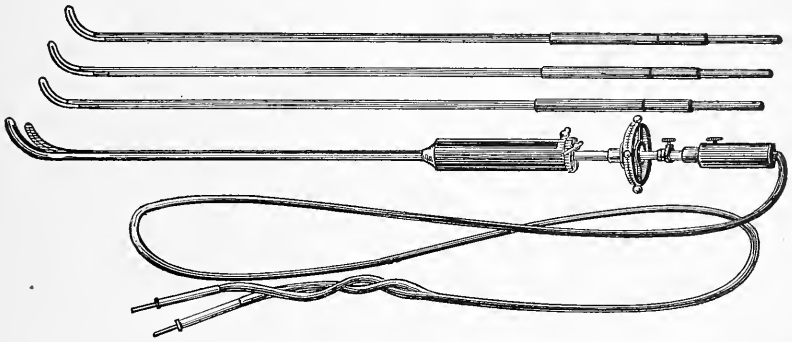


Fig. 736.—Young's modification of Freudenberg's instrument for prostatotomy by galvanocautery.

Bottini's operation is the procedure to be selected for a sclerotic prostate, and for hypertrophy in a feeble and aged individual with damaged kidneys.

Fig. 737.—Incisions of the middle lobe (Young).

It is not probable that the cautery operation will replace prostatectomy. The best instrument is Young's modification of Freudenberg's apparatus (Fig. 736). Figs. 737 and 738 show various methods of making the cuts as advised by Hugh H. Young. When there is a distinct and pedunculated median lobe,

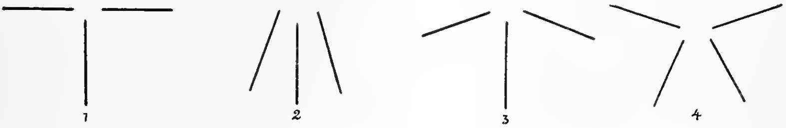


Fig. 738.—Different incisions of prostate gland in Bottini's operation (after Young).

* For description of this operation see Freudenberg, in Berliner klin. Woch., No. 46, 1897; and Willy Meyer, in Med. Record of March 5, 1898, and May 12, 1900.

the ordinary operation fails entirely; but, as Young shows (Figs. 737, 739), if an oblique cut is made on each side across the base, this lobe will drop out of the way and quickly atrophy.

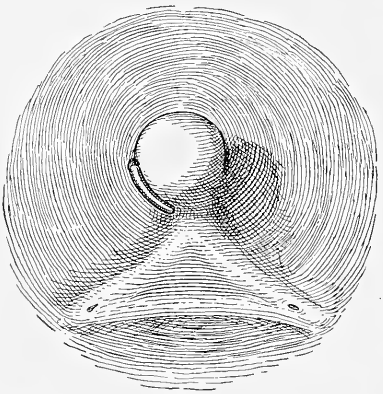


Fig. 739.—Incising the middle lobe (Young).

Castration and Vasectomy.—In 1886 Sanitzin demonstrated clinically the shrinking of a large prostate after double castration (Hawley, in "Annals of Surgery," Nov., 1903). In 1893 Ramm, of Norway, performed double castration in order to cause shrinking of an enlarged prostate. In 1893, after a long series of careful experiments, J. William White recommended the operation of bilateral orchidectomy for the treatment of prostatic hypertrophy. He proved that removal of the testicles causes a rapid shrinking in an enlarged prostate. Much of this shrinking may be due to diminution of congestion and edema, but true atrophy undoubtedly occurs in the glandular elements. Very remarkable results have been recorded. In some cases the patients become absolutely comfortable and dispense entirely with the catheter. Cystitis ceases, and desire to urinate frequently becomes less marked. Unilateral orchidectomy has been employed, but it is not satisfactory. In 1894 Mears suggested ligation of the spermatic cord. In 1895 Lauenstein suggested division of the spermatic cord. In 1896 Tilden Brown suggested ligation of the vas. Reginald Harrison in 1896 advised section of the vas. Lennander in 1897 proposed exsection of the vas deferens (*vasectomy*). It is slower in its results, but just as certain as castration. In spite of the great simplicity of orchidectomy the mortality has been considerable (from 11 to 18 per cent., according to some authors. Socin and Burckhardt say 16.2 per cent.). In several instances mental disturbance has followed the operation, but there is no real evidence that it was due to this special form of operation and would not with certainty have followed any other. Castration is now very seldom performed, as vasectomy is just as useful. Vasectomy is valueless in cases of fibroid prostate, does some good in adenoma, but is most valuable when the prostate is generally hypertrophied and prone to great congestion causing violent symptoms.

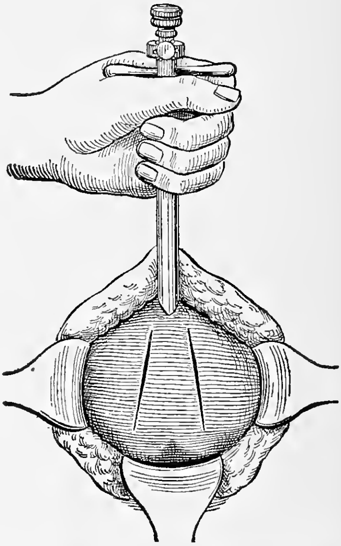


Fig. 740.—Tractor introduced; blades separated; traction made, exposing posterior surface of prostate. Incisions in capsule on each side of ejaculatory ducts (Young).

Other Methods.—Among other operations which have been suggested are: ligation of the vascular elements of the cord; resection of all the cord elements except the vas and its artery and vein (*angioneurectomy*, proposed by Albarran in 1897); parenchymatous injections of cocain into the testicles; and ligation of both internal iliac arteries. Angioneurectomy has a mortality of 5.5 per cent. (Socin and Burckhardt).

Results.—The relative merits of these various operations alluded to above are in dispute. It is certain that many cases of prostatic hypertrophy can be kept comfortable by aseptic catheterism. If this procedure fails, or for other reasons must be abandoned, or if the surgeon decides not to employ it, a careful study of the case should be made before selecting a special operation. The Bottini operation has come into somewhat extensive use. Some would apply it to almost any sort of case, and claim that the operation is practically free from danger. Meyer uses it for any case of uncomplicated hypertrophy, but if the prostate is very large, ligates the vasa deferentia some weeks before cauterizing the prostate, in order to lessen the danger of thromboses.

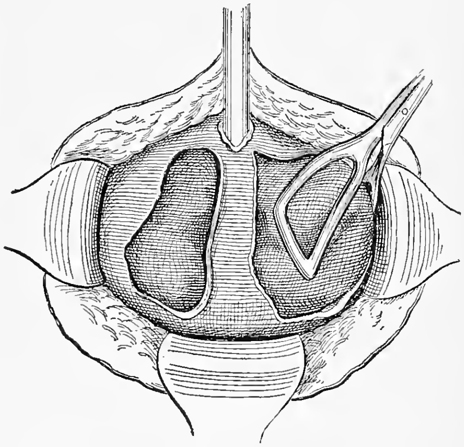


Fig. 741.—Enucleation of lobes. Forceps in position (Young).

A more conservative view is that of Eugene Fuller, who doubts the permanence of the results of the Bottini operation, fears that stenosis of the vesical neck may follow, and would restrict the operation to uncomplicated cases, not of a grave character, and in which the bladder has not been seriously damaged. It is the operation of choice if the prostate is fibrous; Horwitz prefers it if the patient is old, debilitated, or the victim of kidney disease. Some residual urine usually remains after a Bottini operation. In over 10 per cent. of cases no benefit follows. Vasectomy is used for an engorged and generally enlarged prostate. It may do great good and may fail completely. If the urine is extremely foul, some operation permitting drainage is advisable. In an adenomatous prostate in which enucleation is easy we should prefer the perineal method. In other cases in which it is probable enucleation will be hard; in cases of uncertain diagnosis; in cases in which a calculus may exist; and in cases in which the middle lobe is at fault, do a suprapubic operation, although sometimes a perineal incision may be made, and a cut be made in the prostate to bring the floor of the urethra level with the trigone.

In old men with great obstruction and with serious disease of the bladder and involvement of the kidneys, and in individuals with prostatic cancer, permanent suprapubic drainage is sometimes the most useful procedure.

The mortality from Bottini's operation is over 5 per cent. Horwitz collected 888 operations: 84.3 per cent. were cured or improved; 10 per cent.

were not improved; and 5.7 per cent. died ("Phila. Med. Jour.," Nov. 16, 1901). Young had 3 deaths in 41 operations.

Vasectomy done early gives a mortality of from 3 to 5 per cent. If performed later, the mortality is 10 to 15 per cent. Socin and Burckhardt estimate the mortality of bilateral vasectomy as 8.3 per cent. The mortality of bilateral orchidectomy is 16.2 per cent.

The mortality of prostatectomy is variously estimated. Freudenberg collected 753 cases: 622 were cured, 44 died, and 87 were not improved.

Guitéras collected 152 cases done by various methods ("Jour. Amer. Med. Assoc.," Nov. 2, 1901). Twenty-five died. Bangs believes that the mortality from prostatectomy should not be above 8 per cent., but statistics indicate that it is from 10 to 15 per cent. in most hands. W. Bruce Clarke reports a mortality of 9 per cent. The mortality of the suprapubic operation is higher than that of the perineal operation. Belfield estimates the former at 16 per cent. and the latter at 9 per cent. Watson estimates the mortality of the former as 8.6 per cent. and of the latter as 2.9 per cent.

The earlier the operation is performed, the safer it is. (See "The Choice of Method in Operating Upon the Hypertrophied Prostate," by Willy Meyer, in "Med. Record," Oct. 7, 1905; "A Critical Review of the Technic of Perineal Prostatectomy," by Charles Greene Cumston, in "American Medicine," August, 1906; "The Operative Treatment of the Hypertrophied Prostate," by Francis S. Watson, "Annals of Surgery," June, 1904.)

Malignant Disease of the Prostate Gland.—Primary malignant growths of the prostate are not infrequently encountered, but secondary growths are much more rare than are primary growths. When malignant disease does occur, it is almost always cancerous. Secondary cancer of the prostate finds its most usual antecedent in cancer of the rectum. Epithelioma does not occur. Scirrhus occasionally occurs; but the most frequent form is encephaloid. Round-celled, spindle-celled, or mixed-celled sarcoma may develop.

Carcinoma of the prostate may occur at an earlier age than ordinary hypertrophy of the prostate. The latter does not become evident until after the age of fifty; but carcinoma of the prostate may begin at any time after the age of forty, and sarcoma of the prostate may commence in early youth.

At first the carcinomatous growth enlarges slowly; but it soon begins to grow with rapidity. It breaks through the capsule and fungates into the bladder or into the urethra. The pelvic, the inguinal, and the femoral glands become involved early in the course of the disease. It is not usual to find great obstruction to urination or to the passage of a catheter at an early period, but later both these conditions are noted. Early in the case there is pain only when obstruction to urination occurs; later, the pain in the neck of the bladder may be severe, and there may also be pain in the loin and in the sciatic nerves. Hemorrhage usually occurs. In the beginning the hemorrhage is trivial and intermittent, but when fungation exists, large hemorrhages generally take place. The blood is usually mixed with urine, but there is sometimes a large hemorrhage unassociated with micturition. The urine is not likely to contain pus or any large quantity of mucus unless the bladder is involved in the growth.

When the prostate gland is felt by means of a finger in the patient's rectum,

it is found to be of stony hardness and to be firmly anchored in place. Reginald Harrison points out that an ordinary hypertrophied gland is not so firmly anchored as a carcinomatous gland; that the bowel moves over it with freedom; and that, although it is firm to the touch, it is not of stony hardness. The patient with carcinoma of the prostate loses flesh rapidly and develops distinct cachexia, and metastatic deposits are likely to form in the vertebral column, in the kidneys, and in other organs and structures.

In making a diagnosis Harrison insists upon the value of the cystoscope. He says that in cancer one does not find much intravesical projection, and that what projection there is is uneven and irregular. In an ordinary adenomatous prostate, on the contrary, the surface is smooth and rounded and projects into the bladder.

Treatment.—Radical operation is out of the question in these cases. Permanent suprapubic drainage is made in most instances, and usually gives the patient great relief. (See "Remarks on Cancer of the Prostate," by Reginald Harrison, in "Brit. Med. Jour." of July 4, 1903.)

Tuberculosis of the Prostate Gland.—Tuberculosis of the prostate is rarely primary. It is usually secondary to tuberculosis of the kidney or of the epididymis. In the majority of cases of tuberculosis of the prostate the lungs are involved in a tuberculous process when the patient is first seen by the surgeon. The disease appears particularly between the ages of twenty and thirty years, but it may attack elderly men and even the aged. It begins by the formation of a number of tuberculous nodules in the immediate neighborhood of the prostatic tubules. These nodules caseate and run together, forming cavities and, eventually, tuberculous abscesses, which are prone to rupture into the urethra. In very rare instances a large tuberculous abscess ruptures through the perineum, into the rectum or into the peritoneum.

The disease occasionally undergoes spontaneous cure, through fibrous-tissue formation or calcification. The tuberculous process is liable to spread to the seminal vesicles, the bladder, the ureters, and possibly the peritoneum; and in some cases it inaugurates thrombophlebitis and pyemia.

Symptoms.—The patient suffers with pain during micturition; there is frequent micturition; and from time to time the urine contains blood. Attacks of cystitis take place, and weakness and a loss of flesh are greater than is commensurate with any ordinary inflammation. Tuberculosis of the prostate alone is said not to cause marked hectic fever; but when adjacent structures become involved, the temperature attains a high level and becomes characteristic. When the disease has advanced, there is not unusually urinary incontinence, on account of the involvement of the circular muscular fibers about the neck of the bladder. Commonly, there is a mucopurulent discharge, or mucopurulent matter may be obtained by massaging the prostate. This matter may contain tubercle bacilli, and in some cases the urine also contains these bacilli. Early in the course of the case rectal examination detects some enlargement of the gland, many nodules, and tenderness; later in the disease it finds marked enlargement and areas of softening.

Treatment.—Early in the case Senn recommends parenchymatous injections of iodoform emulsion, the punctures being made through the perineum. If these fail, operation must be considered. When one takes into

account how rare primary tuberculosis of the prostate is, one is impressed with the infrequency with which a radical operation should be attempted. If there is absolutely no evidence that any adjacent organ is involved or that any distant focus of disease exists, it is justifiable to perform perineal prostatectomy. As a rule, however, the only surgical operation performed consists in making a curvilinear incision in front of the rectum, which exposes the prostate, and permits the surgeon to open and curet caseous foci. If an abscess forms, it should be evacuated by means of a perineal incision and cavities should be cureted and packed with iodoform gauze.

If it is determined that no operation is advisable, antituberculous treatment is employed. One should look to the patient's general health, administer urotropin, and avoid using instruments as much as possible; because, as Sir Henry Thompson has shown, instrumentation irritates the prostate, causes a great deal of pain, and makes the disease worse in every case.

Retained and Malplaced Testicle.—The testicle may be arrested in its passage to the scrotum (*cryptorchism*, single or double); it may remain in the lumbar region; it may reach the internal abdominal ring; it may lodge in the inguinal canal; it may emerge from the external ring, but fail to enter the scrotum; or it may pass into an unnatural position, as into the perineum or the crural canal (*ectopia of the testis*). It may be, but seldom is, functionally active, unless it is intra-abdominal. A retained testicle is subject to attacks of orchitis and may become sarcomatous. In 80 per cent. of cases the testicles have descended at birth; most often it is the right testicle which fails to descend. Sometimes a testicle descends after being retained for months or even years. In Keyes' case it descended in the thirtieth year. Late descent usually causes hernia. In double cryptorchism, in which the testicular function has been abolished, there is delayed union of the bony epiphyses and epiphyseal fractures are common, and there may be excessive growth of long bones. The same liability is noted in those subjected to castration in infancy. When such a subject reaches manhood, he may develop some disease of the skeleton which is usually seen only in children (Gross and Sencert, "Rev. de Chir.," No. 11, 1905).

Treatment.—If one testicle is undescended one year after birth, if it lies in the canal, and if the other testicle is sound, the former should be removed if it is found impossible to draw the gland into the scrotum and fasten it. If a testicle is retained in the abdomen, it should not be operated upon unless it causes trouble. Always try to get a retained gland into the scrotum before the age of puberty. If it is retained after puberty, it will be almost certain to be functionally useless, unless it is retained within the belly. An ectopic testicle should be restored to the scrotum if possible; if not, it should be removed. After puberty it will almost certainly prove to be a useless organ.

Orchitis is inflammation of the testicle. *Acute* orchitis may be due to cold, wet, traumatism or epididymitis, gout, mumps, rheumatism, or a specific fever. The testicle is round, swollen, tender, and very painful, the scrotum is red and swollen, the tunica vaginalis is filled with fluid, and there is fever. *Chronic* orchitis results from the acute form or from a chronic urethral inflammation, and is almost always combined with epididymitis.

The **treatment** of the *acute* form consists of rest in bed and applications as for epididymitis (page 1200). The *chronic* form requires the removal of the causative lesion, if possible, the wearing of a suspensory bandage, ap-

plications of ichthyol or mercurial ointment, and the administration of iodid of potassium by the mouth. Strapping may do good. Castration may be required.

Tuberculosis of the testicle may be primary, but in most instances is secondary to tuberculosis of the prostate, bladder, or seminal vesicles. The disease may be preceded by pulmonary tuberculosis, peritoneal tuberculosis, or tuberculous disease of bones or joints; and primary tuberculosis of the testicle may be followed by distant tuberculous lesions. In some cases involvement of the prostate exists, but cannot be detected (*latent tuberculosis of the prostate*); in other cases the prostate is in a state of subacute inflammation. The disease begins in one testicle, but in the vast majority of cases the other testicle becomes involved after a few weeks or months. If but one epididymis is involved, the testicle may not be affected for weeks or months. Von Bruns says that in 18 per cent. of such cases the testicle is not involved for six months; in 40 per cent., for over two months ("Archiv f. klin. Chir.," Bd. 63, H. 4). It may begin in either the epididymis or the testicle. As a rule, it begins in the epididymis and attacks the testicle later. It usually comes on gradually, but it may begin acutely, as I have seen in two instances during the progress of tuberculous peritonitis. The disease is apt to follow a slight injury or inflammation, and is most common in young men, but may arise at any age. Nodules form most commonly in the epididymis, but sometimes in the testicle as well. These nodules soften and run together, and the cord is felt to be enlarged. After a time the skin becomes red and adherent, gives way, and exposes a caseous breaking-down epididymis or testicle. Except in the acute cases, the testicle is only slightly, if at all, painful, and tenderness is trivial. In one-sixth of the cases a small hydrocele forms. In a questionable case the tuberculin test should be employed. If a hydrocele exists, the fluid should be withdrawn by tapping and cultures be made from it.

Treatment.—If the disease is limited to the epididymis or to the epididymis and vas, resect the epididymis (*epididymectomy*) and the vas deferens. If the testicle is diseased, *orchidectomy* is performed. It was long believed that orchidectomy was useless if the vesicles and prostate were involved, but Koenig and others maintain that vesicular and prostatic tuberculosis improves after removing the diseased testicle or epididymis. If the epididymis of each testicle is involved, bilateral epididymectomy should be performed. When both testicles are diseased and other organs and structures are not extensively involved, bilateral orchidectomy is performed, or, better, the testicle which is most diseased is removed and the *diseased portion* of the other is extirpated.

In association with and after operation employ antituberculous remedies, order a nourishing diet, send the patient to a good climate, and insist on an open-air life. A very large percentage of unilateral cases are cured by operation (over 40 per cent.). Some few bilateral cases are cured.

Orchidectomy, or Castration (*Excision of a Testicle*).—In this operation an incision is made over the cord, commencing just outside the external ring and running down over the base of the tumor. Clamp the cord and divide it near to the ring, remove the testicle, ligate the spermatic artery alone, and then ligate the entire thickness of the cord. The cord is ligated with chromic gut. The skin is sutured with silkworm-gut. Drainage is not required. It is often advisable to remove a considerable amount of scrotal skin.

Epididymitis, or inflammation of the epididymis, is usually due to inflammation of the urethra. It is apt to occur in the stage of decline of a gonorrhea, and is announced by a complete cessation of the discharge. It may result from the passage of a urethral instrument, the voiding of urine which contains fragments of calculi, or as a complication of prostatic hypertrophy. *Acute* epididymitis is characterized by swelling about the testicle, pain in the groin, and tenderness over the posterior part of the testicle. The pain becomes acute, swelling rapidly increases, and the constitution sympathizes. The swelling is due partly to engorgement of the epididymis and partly to fluid in the tunica vaginalis (*acute hydrocele*). *Chronic* epididymitis is usually linked with orchitis, and it follows an acute attack or a chronic urethral inflammation.

Treatment by aseptic puncture with a tenotome, if fluctuation is marked, will relieve tension and pain. Leeching over the external abdominal ring, the use of an ice-bag, elevation, application of guaiacol, and administration of laxatives and opium constitute the usual treatment in the acute stage. Applications of guaiacol over the cord, epididymis, and testicle seem to relieve pain and distinctly lessen swelling. Two applications a day should be made for one week. At each application paint the scrotum and over the external ring with 15 drops of guaiacol in 1 dram of glycerin or olive oil. Strapping is employed as the inflammation subsides. The treatment of the chronic form is the same as that for chronic orchitis.

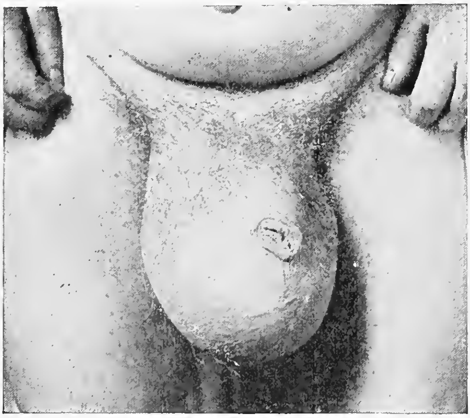


Fig. 742.—Hydrocele of tunica vaginalis (Horwitz).

Strangulation of the Cord by Axial Rotation.—In nearly one-half of the cases the testicle is undescended or only partly descended. In every case there is a long mesorchium, and if a normal testicle is normally placed, torsion of the cord will hardly occur (Chas. L. Scudder, "Annals of Surgery," Aug., 1901). The twisting may be toward the right or toward the left. The symptoms arise suddenly, and usually during exertion. In some cases a hernia also exists. When the rotation occurs, the testicle swells, hemorrhages take place into it, and gangrene may occur. If the cord of an undescended or partially descended testicle twists, swelling and tenderness are noted in the abdomen or the groin. If the swollen testicle is in the scrotum, the gland feels nodular and the epididymis is anterior. The symptoms are sudden pain, vomiting, moderate shock, and a swelling in the groin or a swollen testicle in the scrotum. The swelling receives no impulse on coughing. The symptoms resemble those of strangulated hernia, but are less violent, and the bowels are not obstructed.

Treatment.—An incision should be made, and if the twisting was recent and the testicle is not gangrenous, untwist and fasten the testicle to the scrotum

by a catgut stitch. If the testicle is gangrenous, remove it. Scudder tells us that in 88 per cent. of cases the testicle is found to be gangrenous. According to Scudder, there are 32 cases on record: 31 were operated upon and 1 was not, but all recovered; in 3 the testicle sloughed and in 2 it atrophied ("Annals of Surgery," Aug., 1901).

Vaginal hydrocele (*chronic hydrocele*) (Fig. 742 and Fig. 744, *e*) is a collection of fluid in the tunica vaginalis testis. An enlargement of the testis may cause it, but in most instances the cause is unknown and no signs of inflammation exist. The fluid is albuminous, but it does not coagulate spontaneously; it is thin, straw-colored, and may contain crystals of cholesterin. The testicle is at the lower and back part of the sac. The pyriform mass fluctuates, is translucent, grows from below upward, and the introduction of an exploring-needle permits the yellow fluid to flow out. Sometimes a hydrocele has an hour-glass shape. This is the *hydrocele "en bissac"* of the French. In this condition (Fig. 743) two cavities exist, usually but not invariably communicating. The constriction between the cavities is due to inflammatory thickening.

Fig. 743.—Hydrocele en bissac. This hydrocele extends up the cord into the inguinal canal and to the internal abdominal ring (Horwitz).

Treatment.—Simply tapping the sac with a trocar is only palliative; air must run in as fluid runs out, and suppuration may occur, which will be dangerous without drainage. Never tap a rigid sac. The injection of irritants should be abandoned, as it exposes the patient to serious danger because of inflammation occurring without provision for drainage. Hearn incises the sac, dries its anterior with bits of gauze, swabs it out with pure carbolic acid, packs it with iodoform gauze, and dresses it antiseptically. The packing is removed in twenty-four hours and the wound is allowed to close. In most

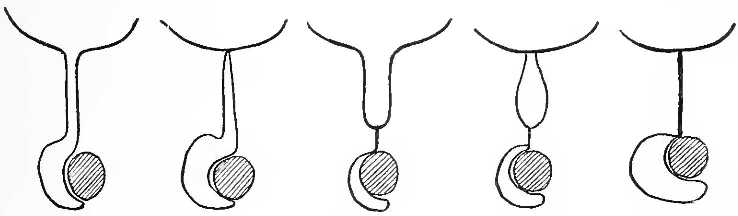


Fig. 744.—Varieties of hydrocele: *a*, Congenital; *b*, infantile; *c*, funicular; *d*, encysted, *e*, vaginal.

cases I prefer this method. If the sac is rigid and will not collapse, either stitch it to the skin and pack it or excise a large portion of its parietal layer and insert a drainage-tube (*Volkmann's operation*). It has recently been proposed to tap the sac with a trocar and cannula, to leave the cannula in place as a drain for some days, and to dress antiseptically.

Longuet's operation is easy and successful. It is called *extraserous transposition of the testicle*. It was introduced by Longuet in 1898 ("Progrès Méd.," Sept. 21, 1901). A local anesthetic is injected and an incision two inches in length is made. The testicle is lifted from the scrotum. The serous and all the other coats except the skin fall together behind and make a sheath for the cord. One catgut suture will hold them behind the cord. A bed is made for the testicle beneath the inner edge of the skin wound, by tearing with the fingers. The testicle is rotated on its long axis and inserted into this cavity. The testicle rests against the scrotal septum, and in front of the gland is the cord covered with tunic. The skin is sutured and the wound is dressed.

Congenital hydrocele (Fig. 744, *a*) is hydrocele through an unclosed funicular process into the tunica vaginalis. If the pelvis is raised, the fluid runs back into the peritoneal cavity, from which it originally came. The **treatment** is the application of a truss to obliterate the funicular process.

Infantile hydrocele (Fig. 744, *b*) is a collection of fluid in a funicular process and the tunica vaginalis, the funicular process being closed above, but not below. The **treatment** is to puncture the sac and to scarify the sac-wall with a needle.

Encysted Hydrocele of the Cord (Fig. 744, *d*).—In this variety the funicular process is obliterated above and below, but it is patent between these two points and fluid collects. The **treatment** is the same as that for infantile hydrocele. If this fails, incise and pack.

Funicular Hydrocele (Fig. 744, *c*).—The funicular process is closed below, but is open above. Raising the pelvis causes the fluid to trickle back into the peritoneal cavity. The **treatment** is the application of a truss.

Encysted hydroceles of the testicles and of the epididymis may occur. *Diffused hydrocele* of the cord is simply edema of the cord. *Hydrocele of a hernia* is the distention of a hernial sac with peritoneal fluid.

Hematocele (Fig. 745).—*Vaginal hematocele* is blood in the tunica vaginalis, the result of traumatism, a tumor, or the tapping of a hydrocele. There is a pyriform tumor, which fluctuates, but which gradually becomes firmer; the scrotum is livid, and the testicle is below and posterior to the tumor. The *encysted* form of *hematocele of the cord* is a hydrocele of the cord into which bleeding has occurred. The *diffused* form is due to extravasation of blood into the cellular substance of the cord. *Encysted hematocele of the testicle* is due to effusion of blood into an encysted hydrocele of the testicle. *Parenchymatous hematocele* is extravasation of blood into the substance of the testicle.

The **treatment** of a recent case of vaginal hematocele is to put the patient to bed, support the scrotum, and apply an ice-bag over the testicle. If the swelling does not soon abate, incise, irrigate, and pack.

Varicocele is varicose enlargement of the veins of the venous plexus of the spermatic cord. The veins are thickened, lengthened, dilated, and convoluted. The assigned causes are straining, cough, constipation, and an occupation requiring prolonged standing. Some believe ungratified sexual

desire is a cause. Hereditary predisposition is probable. There are more left-sided than right-sided varicoceles, because the right spermatic vein has valves and empties into the vena cava at an acute angle, but the left spermatic vein has no valves (Brinton) and empties into the left renal vein at a right angle. Varicocele is a very common condition. The elder Senn found it in 21 per cent. of 10,000 recruits. An irregular swelling exists in the scrotum and extends up the cord. This swelling feels like "a bag of earth-worms"; it exhibits a slight impulse on coughing; the scrotal skin and cremaster muscle are attenuated; the testicle lies at the bottom of the swelling and is softer and smaller than normal; the swelling diminishes on lying down and increases on standing or on making pressure over the external ring. The scrotum is pendulous and the scrotal skin frequently contains varicose veins. The testicle may be soft and shrunken. There is usually some discomfort, aching,

Fig. 745.—Acute hematocele of tunica vaginalis the result of traumatism (Horwitz).

or dragging in the testicle and the groin, and even neuralgic pain in the cord. There may be no discomfort of any sort. A large varicocele may be free from discomfort and a small varicocele may produce much annoyance, or *vice versâ.* There are sometimes mental depression and hypochondriasis. As a man reaches middle age a varicocele usually ceases to give trouble.

Treatment.—In treating varicocele, reassure the patient: tell him there is no real danger of impotence; order cold shower-baths, correct constipation and indigestion, give occasional tonics, and order the patient to wear a suspensory bandage. If the testicle becomes much atrophied, if the pain and the dragging are annoying, or if the mind is much depressed, operate (page 397).

XXXVII. AMPUTATIONS.

An amputation is the cutting off of a limb or a portion of a limb. Removal of a limb or a portion of a limb at a joint is known as "disarticulation." Amputation may be necessary because of the existence of severe injury, of gangrene, of tumors, of intractable disease of bones or joints, of ulcers which will not heal, of traumatic aneurysm, etc. A re-amputation may be required because of the existence of a defect or disease in the stump.

Classification.—Amputations are classified as follows: (1) As to time of operation after the injury: a *primary* amputation is performed soon after the occurrence of the accident—as soon as the sufferer reacts from shock, and before he develops fever; a *secondary* amputation is performed some time after the accident, suppuration having supervened (Stokes); and an

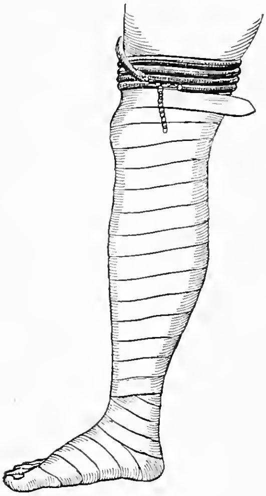


Fig. 746.—Esmarch's elastic bandage.

Fig. 747.—Application of tourniquet.

intermediate amputation is performed during the existence of fever, but before the development of suppuration. (2) As to the situation, where the bone is divided or according to which joint is cut through. (3) As to the form and situation of the flap.

In performing an amputation maintain rigid asepsis; completely remove the hopelessly damaged portion; sacrifice as little of the sound tissue as possible; prevent hemorrhage during the amputation, and carefully arrest it after the operation; have enough sound tissue in the flap to *cover* the bone, and enough skin to cover the muscles; and secure drainage at a dependent point.

Hemorrhage may be prevented by the elastic bandage of Esmarch (Fig. 746). Ordinarily we can apply this bandage from the periphery to well above the line of the prospective incision, encircle the limb with an elastic band (not the thin tube shown in the cut), and remove the bandage. The bandage and band, asepticized before using, are applied to the limb, which has been carefully sterilized. After the band has been applied the limb should

not freely or forcibly be moved, because of the danger of tearing muscles which are firmly fixed by the compressing band. When elastic compression is used in an operation the surgeon should be very careful to tie *every visible vessel.* The paralysis of the small vessels induced by pressure often prevents bleeding, and unless their mouths be found and the vessels be tied reactionary hemorrhage will occur. Reactionary hemorrhage is the great danger after the use of the Esmarch bandage, and paralysis or sloughing may also follow

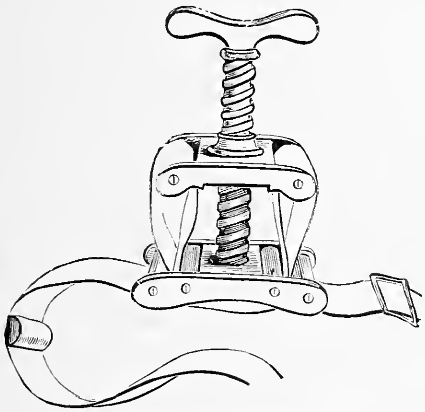


Fig. 748.—Petit's spiral tourniquet.

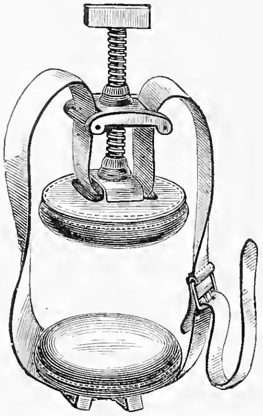


Fig. 749.—Charrière's tourniquet.

its employment. If there be an area of suppuration or of gangrene or an extra-osseous malignant growth, do not apply the bandage as directed above. One bandage can be applied from the periphery to near the lower border of the area of growth or infection, and another, from near the upper border of this area, up the limb. If the bandages are applied in this manner the contents of the diseased area (tumor-cells and fluid or septic products) are not squeezed into the circulation. In cases like the above many surgeons

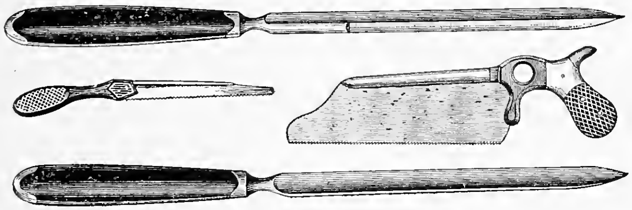


Fig. 750.—Catlin, knife, and saws for amputation.

hold the extremity in a vertical position for five minutes, lightly stroking it toward the body with the hand, and at once apply the constricting band. As a matter of fact, this plan satisfactorily empties the limb of biood, and it is not necessary in any case to force the blood out by elastic compression. Some surgeons prefer the tourniquet. Figs. 748 and 749 show two forms of tourniquet. To apply Petit's tourniquet, place the plates in contact, apply a small, firm compress over the artery and a broad thick compress over the outer surface of the limb, buckle the tapes around the limb so that the plate

is over the broad pad, and tighten the tourniquet by separating the plates with the screw (Fig. 747). When a tourniquet is applied to arrest bleeding during transportation, bandage the limb, sew the compress pad to a bandage, and place the plates of the instrument over the pad. Signorini's horseshoe tourniquet may be used upon the brachial artery. In hip-joint and shoulder-joint disarticulations Wyeth's pins are passed, and after the limb is emptied of blood the band is fastened above them. These pins prevent the bands from slipping.

The instruments and appliances required for amputation are Esmarch's apparatus or tourniquet, amputating knives (Fig. 750), a bone-knife, scalpels, saws (Fig. 750), a lion-jawed forceps, bone-cutting forceps, a periosteum-elevator, retractors of linen, dissecting, hemostatic, and toothed forceps, a tenaculum, an aneurysm-needle, a probe, scissors, needles, ligatures, sutures of silkworm-gut, dressings, bandages, and solutions. A retractor has two tails for the thigh and arm and three tails for the leg and forearm: it is made by taking a piece of muslin eight inches wide and twelve inches long and cutting tails on one side eight inches in length.

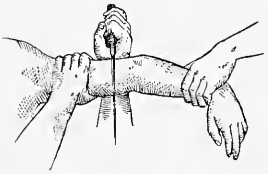


Fig. 751.—Amputation of arm by the circular method (Druitt).

Methods of Amputating.—Transverse Circular Method (Figs. 751 and 752).—This is the oldest method of amputating. The common circular incision is at a right angle to the axis of the limb. Kocher considers also as a circular incision an oblique cut around the limb if the line of the incision "continues in one direction" (Kocher's "Text-Book of Operative Surgery," translated by Harold J. Stiles). This method is called the *oblique circular amputation*. A *racket incision* is formed by adding a longitudinal cut to a transverse circular cut. If the edges are rounded, the *lanceolate incision* is formed. *Rectangular flaps* are formed when two longitudinal incisions are added to a transverse circular cut. If the corners of a rectangular flap are trimmed, *rounded flaps* are formed. The three last-mentioned plans are considered under the head of the Modified Circular Amputation (page 1207).

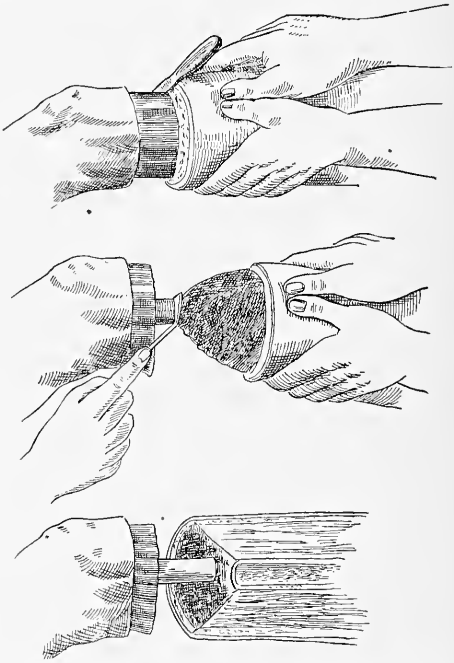


Fig. 752.—The steps of a transverse circular amputation (Kocher).

The surgeon should stand to the right of the limb and use a long amputating knife which cuts

from heel to point (Fig. 751). After an assistant has retracted the skin the operator divides the soft parts by a series of circular cuts. He does not cut at once to the bone, but divides the skin and subcutaneous tissues. At the retracted edge of the first cut the superficial muscles are divided, and after these muscles retract the deep muscles are divided. The periosteum is incised with a bone-knife and pushed up with an elevator, and after the application of the retractors the bone is then sawed, the saw starting from heel to point. A periosteal flap can be made to cover the end of the

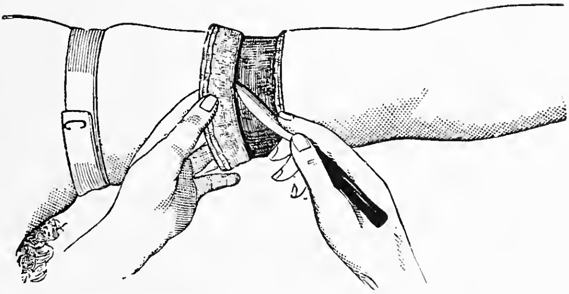


Fig. 753.—Circular amputation; dissecting up the skin-flap (Esmarch).

bone, but it is unnecessary. In this amputation is formed a cone whose apex is the bone and whose base is the skin-edge. Figure 752, from Kocher, shows the steps of the operation and the shape of the resulting stump. In one form of circular amputation (*amputation à la manchette*) the retracted skin is cut by a circular sweep of the knife, a cuff of skin and subcutaneous tissue is freed and turned up, and the muscles are cut circularly at the edge of the turned-up cut (Fig. 753). The pure circular amputation is performed on the arm and the thigh; the amputation *à la manchette* is performed chiefly through the wrist and the lower forearm.

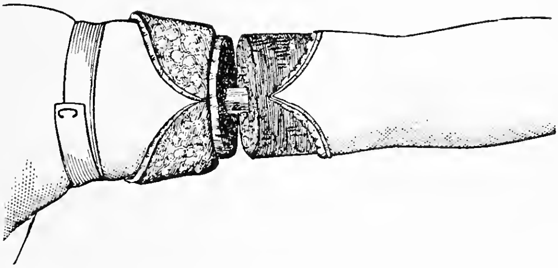


Fig. 754.—Modified circular amputation; skin-flaps and circular cut through muscles (Esmarch).

If there is more sound skin upon one side of the extremity than upon the other, the transverse circular incision sacrifices more of the limb than is necessary and the oblique circular is preferable. An objection to the transverse circular incision is that the cicatrix lies directly at the end of the stump and is liable to cause pain when subjected to pressure.

Modified Circular Method.—In this operation the circular skin-cut may be modified by making a vertical incision to join the first wound, the

muscles being cut by a circular sweep (racket incision) or by making two vertical skin-incisions (rectangular flaps). The lanceolate incision is made by rounding the edges of the flaps which result from a racket incision. Liston's modification consists in dissecting up two short semilunar integumentary flaps and in dividing the muscles circularly (Fig. 754). This is known as the "mixed method." The modified circular can be used upon the thigh, the leg, the arm, and the forearm.

Oblique Circular Method (Elliptical Method).—Mark the upper and lower ends of the incision as shown in Fig. 755. The lowest incision is at a right angle to the cutaneous surface; the highest incision is parallel to the cutaneous surface (Kocher). The skin and fascia are divided so that an oblique incision to the muscles surrounds the limb. The distal elliptical portion of skin is picked up and drawn toward the body and the muscles are divided to the bone, the knife being held transversely (Fig. 755). Kocher points out that this flap increases in thickness toward the bone. The rest of the muscles are divided on a level with and in the direction of the skin-edge. The periosteum is cut transversely and is treated as in the transverse circular operation. The flap of muscle and integument is brought over the wound. This method stands midway between the circular operation and the operation by a single flap, and is employed particularly in certain disarticulations.

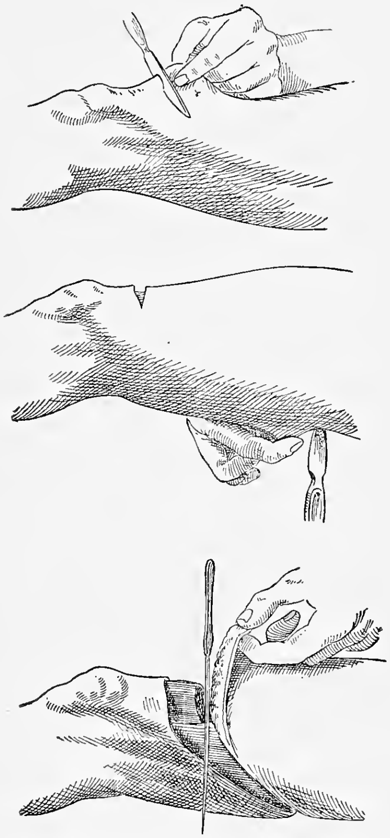


Fig. 755.—The early steps of an oblique circular amputation (Kocher).

Racket Method.—(If flaps are rounded, is known as the "oval" or "lanceolate" incision.) In an *oval* amputation the incision through the skin and subcutaneous tissue is an oval with a pointed end or a triangle; and the other parts down to the bone are cut from without inward. When a longitudinal incision down to the bone (Fig. 765, *a*, *b*) extends from the point of the oval, the operation is called the "racket" amputation. If the longitudinal cut joins a circular cut, the operation is known as a T-amputation. The oval or racket operation is performed at the metacarpophalangeal, metatarsophalangeal, and shoulder-joints; the T-operation may be performed at the hip-joint.

Flap Method.—A flap may be composed of *skin* only or of both *skin* and *muscle*, but the skin-flap must always be longer than the muscle-flap, so that the latter will be covered by it. A flap containing much muscle heals badly, but the best flap has a moderate amount of muscle (enough skin to

cover the muscle and enough muscle to cover the bone). Flaps may be *single* or *double*. Double flaps may be *lateral* or *antero-posterior*, *square* or U*-shaped*, *equal* or *unequal*, and they may be cut by *transfixion* (Fig. 756), by cutting from without inward, by dissection, or by cutting the skin from without inward and the muscles by transfixion.

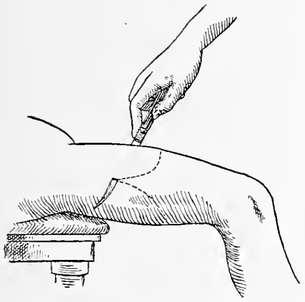


Fig. 756.—Amputation of the thigh by transfixion (Gross).

Completion of an Amputation.—When an amputation is completed, tie the main vessels, pull down the nerves and cut them high up, smooth the flaps, take off the constricting band, and after arresting hemorrhage apply sutures. In some cases the deep parts are stitched with a continuous catgut suture and the superficial parts are closed with silkworm-gut; in other cases the deep parts are not stitched at all, the skin alone being sutured with silkworm-gut. Drainage-tubes should be used except in amputations of the fingers and toes.

Special Amputations.

Fingers and Hand.—In amputating the thumb and index-finger save every possible scrap of tissue. In either of the fingers, if it be necessary to amputate above the middle of the middle phalanx, the attachment of the flexor tendons will be cut off and the finger will be liable to project directly backward, so that it is better with these fingers either to disarticulate at the metacarpal joints or to stitch the flexor tendons to the periosteum. The flexor tendons have fibrous sheaths extending from the proximal end of the distal phalanx to the metacarpophalangeal articulations, these sheaths being thin and collapsible opposite the joints, but being thick and rigid opposite the shafts of the bone. The fibrous sheath is known as the *theca*, and when it is cut in an amputation it should be closed, otherwise it may carry infection to the palm of the hand. The theca does not exist over the distal phalanx, and it is not distinctly visible over the joint between the distal and middle phalanges. To effect closure over the shaft of a bone, strip up the periosteum and pass catgut sutures vertically through the theca and the periosteum (Treves). In amputation of the fingers and the thumb an Esmarch bandage is unnecessary, though pressure may be made upon the arteries at the wrist. Only two or three ligatures are necessary. Close with a very few sutures, so as to favor drainage between the threads.

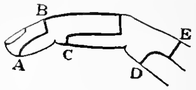


Fig. 757.—Amputation of the finger.

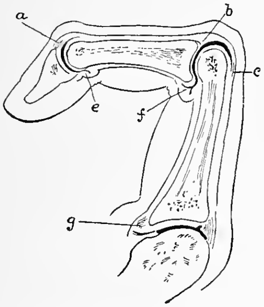


Fig. 758.—The line of the joints in the flexed position of the finger: *a*, Extensor longus digitorum; *b*, interossei and lumbricals; *c*, extensor longus digitorum and interossei; *g*, interossei and lumbricals; *f*, flexor sublimis; *e*, flexor profundus (Kocher).

The distal phalanx is best removed by a long palmar flap (Fig. 757, A).

The palmar flap (A) is marked out by cutting through the skin and subcutaneous tissue. The incisions are next carried to the bone, the flap is dissected from the bone, the finger is strongly flexed, a transverse incision (B) is carried across the dorsum on a level with the base of the third phalanx, the soft parts are pushed back, the joint is opened, the lateral ligaments are cut from within outward, the third phalanx is forcibly extended, and the remaining structures are cut from below upward. Fig. 758 shows the lines of the joints when the finger is flexed. The middle phalanx can be removed by the same method (C, Fig. 757). The proximal phalanx can be removed by a long palmar flap or by a long palmar and a short dorsal flap (D, E, Fig. 757).

Disarticulation at a metacarpophalangeal joint is best performed by the oval method. The incision upon the dorsum (A) is begun just above the head of the metacarpal bone, is carried down to beyond the base of the phalanx, and involves the skin only (Figs. 759 and 760). One incision sweeps around the finger at the level of the web, going only through the skin (B); the finger is extended and the palmar cut is carried to the bone; each lateral incision is carried to the bone while the finger is bent in the opposite direction, the flaps are dissected back to the joint, the finger is strongly extended, the joint is opened from the palmar side, and disarticulation is effected. Cutting off the head of the metacarpal bone improves the appearance of the stump but weakens the hand, hence in a workingman it must not be done unnecessarily. If it is necessary to remove a metacarpal bone, the incision (C) is made from the carpometacarpal joint.

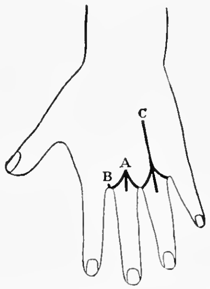


Fig. 759.—A, Disarticulation of a metacarpophalangeal joint; C, amputation of a finger with the metacarpal bone.

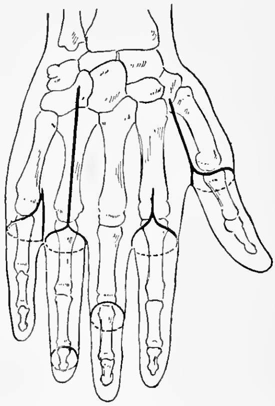


Fig. 760.—Disarticulation of the little finger and index finger. Disarticulation of the ring finger with its metacarpal bone. Disarticulation of the thumb with its metacarpal bone (Kocher).

Amputation of the thumb through its distal or proximal phalanx is performed identically as is an amputation of a finger. Amputation of the thumb, with a portion or the whole of its metacarpal bone, is performed by the oval or racket incision (Fig. 760).

Disarticulation at the wrist-joint can be done by the oblique circular method (Fig. 762) or by a double flap. In the double-flap amputation a dorsal flap is made by carrying a semilunar skin-incision between the styloid processes; the skin is lifted, the wrist is forcibly flexed, the joint is opened

by a transverse cut, and a long semilunar palmar flap which includes only the skin and fascia is made by dissection. Kocher prefers to amputate by an oblique incision. The lower end of this incision is about the middle of the palm and the upper end is in the line of the wrist-joint (Fig. 762). The hand is strongly flexed, the extensor tendons are divided, the posterior ligament of the joint is incised, and incisions below the styloid processes divide the lateral ligaments and certain tendons. The flexor tendons are separated from the bone and are divided so as to remain in the palmar flap.

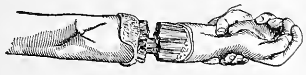


Fig. 761.—Modified circular amputation of the forearm (Bryant).

Amputation through the forearm may be effected by the circular method (Fig. 762), the modified circular, or the flap operation. The modified circular is an excellent plan. A semilunar dorsal skin-flap and a semilunar skin-flap on the flexor surface are made. The flaps are raised, the muscles are

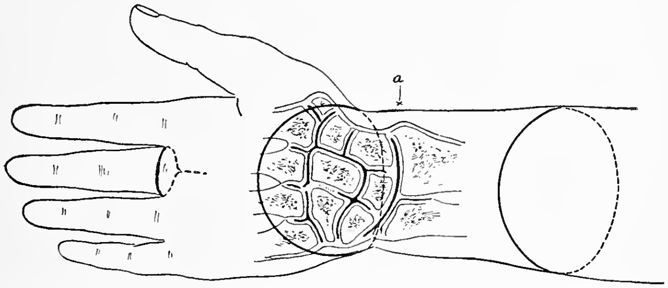


Fig. 762.—Disarticulation of the middle finger. Disarticulation at the wrist-joint. Amputation through the forearm by the oblique circular method (Kocher).

cut circularly (Fig. 761), the interosseous space is cleared with the knife, a three-tailed retractor is applied, the periosteum is pushed up, and the bones are sawn half an inch above the flap. In sawing the bones, start the saw upon the radius, draw it from heel to point, make a furrow on the radius and

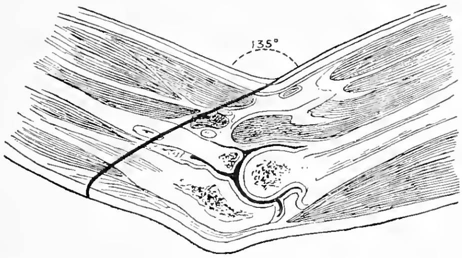


Fig. 763.—Disarticulation of the elbow-joint by the oblique circular method (Kocher).

ulna, and saw both bones at the same time. After sawing, cut away any irregular edge with bone-pliers. In the lower third Teale's amputation may

be done, the dorsal flap being the long one. In Teale's amputation rectangular flaps are made. The long flap is equal in width and length to one-half the circumference of the limb at the point where it is to be sawn. The short flap is equal in width to the long flap, but is only one-fourth its length. The two longitudinal cuts are at first taken only through the skin, but the two transverse cuts go at once to the bone. The flaps are dissected up from the interosseous membrane and the bone. In the middle or the upper third of a fleshy arm two semilunar skin-flaps can be cut from without inward, and the muscle can be cut by transfixion.

Disarticulation at the elbow-joint can be done by the elliptical method or by a long anterior and short posterior flap. In Kocher's oblique operation the incision begins anteriorly over the joint-line and ends posteriorly a hand's breadth below the summit of the olecranon (Fig. 763). A posterior flap which contains the integument, insertion of the triceps, the anconeus, and periosteum is dissected up until the posterior surface of the humerus is reached. The joint is opened anteriorly by a transverse incision,

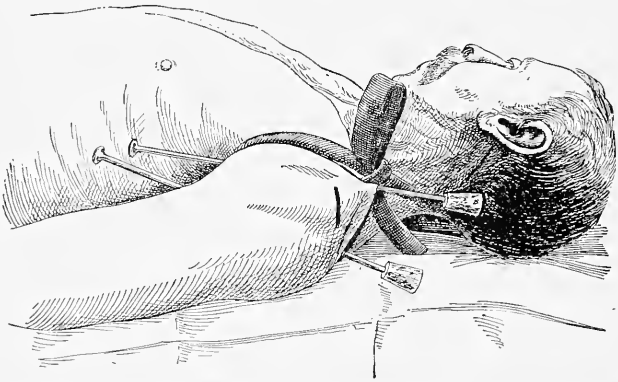


Fig. 764.—Use of Wyeth's pins in amputation at the shoulder-joint. The acromion is marked by a black line (Keen).

and the radiohumeral articulation is opened from without inward (Kocher). In the double flap operation the forearm is partly flexed and a skin-cut marks out a long anterior flap, the knife being entered opposite the external condyle and being withdrawn one inch below the internal condyle. The muscles, which are bunched forward, are cut by transfixion. A posterior semilunar flap is made, which separates the attachments of the radius, the ulna is cleared, and the triceps is cut at its insertion (Bell). Gross advocated sawing through the olecranon and the inner trochlear surface.

Amputation of the arm is best performed by marking out with a knife two equal semilunar anteroposterior flaps, the first cut being carried through the skin alone, the muscles being then transfixed with a long knife. Teale's method is shown in Figs. 334 and 335. The circular or the modified circular amputation may be performed.

Disarticulation at the Shoulder-joint.—In this operation some surgeons use Wyeth's pins to hold the Esmarch band in place. The anterior pin is entered at the middle of the lower margin of the anterior axillary

fold, and emerges one inch within the tip of the acromion. The posterior pin is entered at a corresponding point on the posterior axillary fold, and emerges more posteriorly than the first pin and an inch within the tip of the acromion. After the extremity has been drained of blood by the Esmarch bandage or by stroking and a vertical position, the Esmarch band is applied above the pins (Fig. 764). With a competent assistant, however, the pins are not necessary, the surgeon divides his main vessels as the last step of the operation, and the assistant controls them before they are cut and until they are tied, with his thumbs slipped back of the bone.

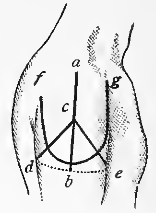


Fig. 765.—Amputation at the shoulder-joint: *a*, *b*, *c*, *d*, *e*, Larrey's operation; *f*, *g*, Dupuytren's operation.

Larrey's Operation.—In this method of shoulder-joint disarticulation the limb is held from the side and an incision is made down to the bone, the incision beginning just below and in front of the acromion and running vertically for four inches down the outer surface of the arm (Fig. 765, *a b*). From the center of this incision an oval incision (*c d*, *c e*) is carried around the arm, the inner aspect of the oval reaching as low as the lower end of the vertical cut. The oval incision at first involves only the skin and subcutaneous tissues. The anterior structures are divided close to the bone, and the posterior structures are next cut. To disarticulate, cut the capsule transversely upon the head of the bone; while the arm is rotated outward cut the subscapularis, and while the arm is rotated inward cut the supraspinatus and infraspinatus and the teres minor. Cut away any

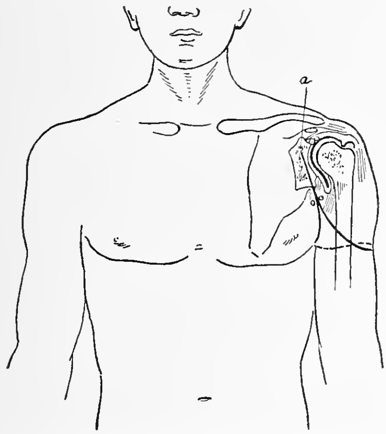


Fig. 766.—Disarticulation at the shoulder-joint by Kocher's method (Kocher).

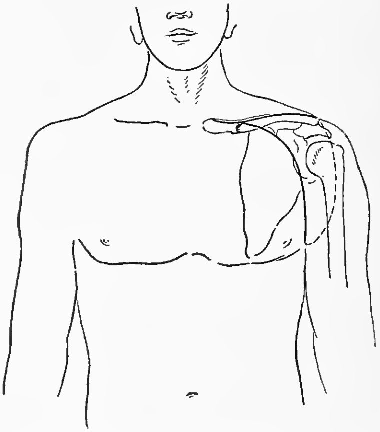


Fig. 767.—Removal of the entire upper extremity (Kocher).

tissue holding the humerus to the body, hanging nerves, capsule-fragments, and tissue-shreds, insert a tube, and sew up the wound vertically. Bell advises an oval incision with a racket handle. Spence used an anterior racket incision.

Kocher's Operation.—Kocher makes an anterior lanceolate incision (Fig. 766). The incision begins over the clavicle just external to the coracoid process of the scapula, and is carried downward, dividing, as it advances, the anterior fibers of the deltoid muscle. "Bleeding vessels and the cephalic vein are ligatured. In the upper part of the wound the acromial branches of the

acromiothoracic artery are also ligatured. The knife is carried down to the bone at the edge of the deltoid (only the upper fibers of which have been divided). The capsule is divided over the lesser tuberosity and the bicipital groove. The periosteum, the insertions of the subscapularis, pectoralis major, latissimus dorsi, and teres major are detached along with the capsule. The capsule, along with the insertions of the supraspinatus, infraspinatus, and teres minor muscles, is also detached from the upper part of the head and from the great tuberosity. The head of the humerus can now be protruded from the wound. In cutting down over the surgical neck it may be necessary to ligature the circumflex arteries; in any case the anterior vessel must be tied. The racket incision is now completed by dividing the skin circularly at the level of the axillary folds. The vessels and nerves are then easily isolated, the former being ligatured and the latter divided" (Kocher's "Text-book of Operative Surgery," translated by Harold J. Stiles). Kocher cautions us to avoid the circumflex nerve which supplies the deltoid, as the deltoid is the muscle of the stump.

Dupuytren's Operation.—In Dupuytren's shoulder-joint disarticulation a U-shaped flap is marked out by a skin-incision (Fig. 765, *f*, *g*). If the amputation is to be at the right shoulder, the arm is carried across the chest; the knife is entered at the root of the acromion, follows the margin of the deltoid, and is withdrawn at the coracoid process, the arm being gradually abducted and pulled off from the chest. If the left shoulder is to be amputated, the procedure is reversed (Treves). The knife next cuts through the deltoid and raises a flap composed of this muscle, the shoulder-joint is exposed, and disarticulation is effected as in Larrey's method. The knife is passed down back of the bone and a short internal flap is cut.

Lisfranc's amputation is by transfixion with the formation of an anterior and a posterior flap, and can be performed very rapidly by a skilful surgeon.

Amputation of the Entire Upper Extremity.—Berger's Amputation.—*The Interscapulo-thoracic Amputation.*—This operation, which is an amputation above the shoulder-joint, was described by Berger in 1887. By it are removed the arm, the scapula, and a portion of or the entire clavicle. It is occasionally employed in cases of malignant disease and of severe injury. The operation is attended with profuse hemorrhage, and as a preliminary the subclavian vessels should be ligated. The incisions must be varied according to the necessities of the case. In this operation Berger divides the clavicle at the junction of its outer and middle thirds, and resects the middle third of the bone; ligates and divides the subclavian vessels; cuts the anterior flap; divides the brachial plexus; marks out the posterior flap; and completes the operation by dividing the structures which hold the shoulder-blade to the chest. It is in this last step that bleeding is profuse. Fig. 768 shows Berger's incisions for the operation. Fig. 767 shows Kocher's incisions.

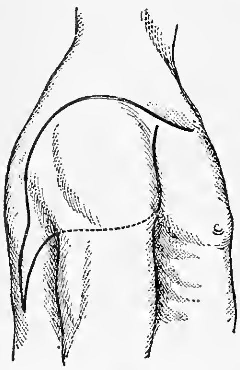


Fig. 768.—Removal of the whole upper extremity.

The usual procedure of tying the third part of the subclavian artery as a preliminary measure possesses certain disadvantages. The

artery is very deeply situated at this point, is in close relation with the pleura, and is covered to a considerable extent by the vein; and the phrenic nerve is very near. Le Conte resects the entire clavicle before tying the vessels. He maintains that then one of two courses may be taken: The veins may be severed first, and afterward the artery may be exposed and tied. When this is done, the amount of blood remaining in the arm is lost. The procedure that he selects as the best, however, is to expose the axillary artery as high up as possible, and place a temporary ligature around it; then elevate the arm, empty it of blood, place a permanent ligature around the third part of the subclavian artery, and divide the artery in this portion of its course (Robert G. Le Conte, "Annals of Surgery," Oct., 1902). If the scapula is involved in the tumor, the mortality is something over 23 per cent. (Berger, "Revue de Chir.," Aug., 1905).

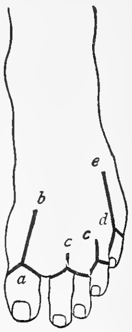


Fig. 769.—Amputation of the toes with and without the metatarsal bones.

Amputation of the Toes and the Foot.—Only through the great toe is *partial* amputation performed, and it is effected by the formation of a long plantar flap, just as a long palmar flap is formed from the finger. Amputation at the metatarso-phalangeal joints is performed by an oval or racket incision (Fig. 769, *c*). Amputation of a toe with removal of its metatarsal bone is shown in Fig. 769, *a b* and *d e*.

Disarticulation at the Tarsometatarsal Articulation.—Lisfranc's Operation (after Treves).—In order to amputate the right foot by this method begin an incision on the outer border of the foot, behind the tubercle of the fifth metatarsal bone; carry the incision forward one inch and sweep it across the foot half an inch below the tarsometatarsal articulations; bring the incision to the inner edge of the foot, half an inch in front of the articulation of the tarsus with the first metatarsal bone, and carry the cut straight back along the inner margin of the foot until it reaches a point three-fourths of an inch above the articulation of the metatarsal bone of the great toe. A very short semilunar dorsal skin-flap is thus formed. Fig. 775 shows the flaps as cut by Kocher. After the skin-flap has been dissected back for a quarter of an inch the tendons are divided, and the flap, which now contains all the soft parts, is dissected back to *above* the joint. A long plantar flap is cut, reaching from the origin of the first flap to the necks of the metatarsal bones. The skin-flap is dissected up until the hollow behind the heads of the metatarsal bones is reached, when, with the toes in extension, the tendons are cut across and a flap composed of all the soft parts is dissected up to above the tarsometatarsal joint. Figs. 770 and 775 show the line of Lisfranc at the tarsometatarsal articulation. The joint is opened from the outer side according to the following rule: in separating the fifth metatarsal direct the edge of the knife toward the distal end of the first metatarsal; in separating the fourth metatarsal direct the knife toward the middle of the first metatarsal; in separating the third metatarsal carry the knife almost directly across. The separation is facilitated by bending down the front of the foot, and at the same time the tendons of the peroneus brevis and tertius are divided. Open

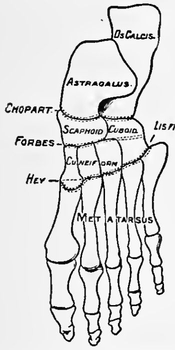


Fig. 770. — Lines in amputations of the foot (Gross).

the joint between the first metatarsal and the inner cuneiform bone, turning the knife toward the middle of the shaft of the fifth metatarsal, and at the same time divide the tibialis anticus muscle. Treves says that in disarticulation of the second metatarsal the knife is to be held as a trocar, it is to be thrust between the base of the first and second metatarsal bones until the point strikes bone (Fig. 771), and is then to be raised to a perpendicular and

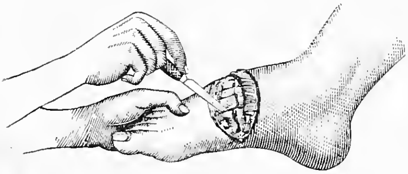


Fig. 771.—Lisfranc's amputation—first step in disarticulating the second metatarsal bone (Guérin).

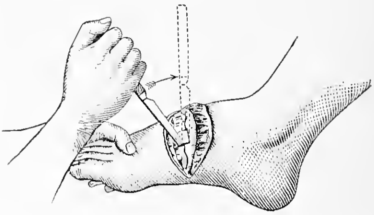


Fig. 772.—Lisfranc's amputation—second step in disarticulating the second metatarsal bone (Guérin).

the cut is to be made toward the external malleolus to sever the ligament of Lisfranc (Fig. 772). Divide any remaining ligaments, and also the tendon of the peroneus longus muscle. The skin-incisions in the *left* foot are begun on the inner side, and in disarticulating the tarsal joint of the great toe is first opened. Fig. 776 shows the parts after disarticulation at the line of Lisfranc.

Hey's Operation.—In Hey's method the incision is practically the same

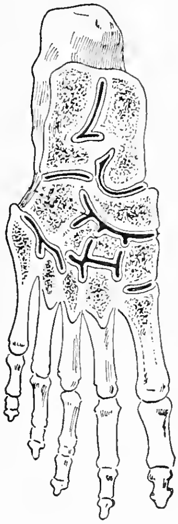


Fig. 773.—Anterior intertarsal disarticulation (Kocher).

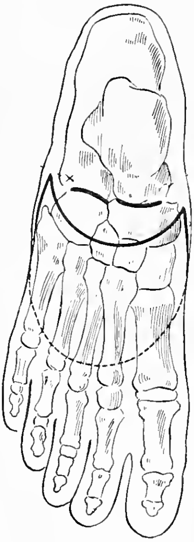


Fig. 774.—Chopart's amputation.

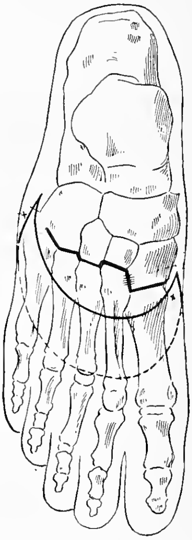


Fig. 775.—Lisfranc's amputation.

as that for Lisfranc's amputation. The four external metatarsal bones are disarticulated, but the first metatarsal is removed by sawing a portion of the

internal cuneiform bone. Guérin advised sawing all the bones across. Skey advised the division of the head of the second metatarsal. Fig. 770 shows the line of Hey.

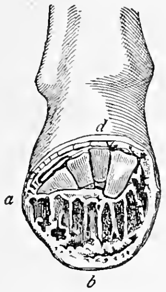


Fig. 776.—The parts after Lisfranc's amputation (Bernard and Huette).

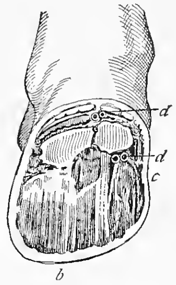


Fig. 777.—The parts after amputation by Chopart's method (Bernard and Huette).

Anterior Intertarsal Disarticulation.—The disarticulation is effected between the three cuneiform bones in front and the scaphoid behind, and the cuboid is sawn across. The incision of the soft parts is as for Lisfranc's amputation (Fig. 773).

Disarticulation through the Middle Tarsal Joint.—Chopart's Operation (Posterior Intertarsal Disarticulation).—Make a transverse incision through the skin of the instep, two inches below the ankle-joint; cut the tendons and muscles, expose the tarsus, and make on each side a small longitudinal incision reaching to below and in front of the corresponding malleolus. The flap thus formed is retracted. The plantar flap is made as in Lisfranc's amputation. The flaps as made by Kocher are shown in Fig. 774. Open the astragaloscaphoid joint, then the calcaneocuboid joint, and disarticulate. Fig. 770 and Fig. 774 show the line of Chopart. Fig. 777 shows the parts after Chopart's disarticulation. In *amputation through the tarsus*, Forbes, of Toledo, advises making flaps as in Chopart's amputation, disarticulating the scaphoid from the cuneiform bones, and sawing through the cuboid. Fig. 770 shows the line of Forbes.

Subastragaloid Disarticulation.—A circular incision is carried around the foot at the level of the middle tarsal joint and a racket incision is added to it running below and posterior to the tip of the external malleolus (Fig. 778). "The joint between the astragalus and scaphoid is opened upon the dorsum, without opening the calcaneocuboid joint. A narrow knife is then passed backward and slightly upward beneath the head of the astragalus so as to divide the strong interosseous ligament between it and the os calcis. The soft parts are then dissected off the os calcis, first from its upper surface, then from its outer and under surfaces, and lastly from its inner and posterior

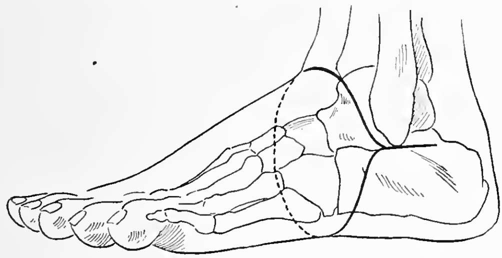


Fig. 778.—Subastragaloid disarticulation (Kocher).

surfaces. The greatest difficulty is met with at the inner side in clearing the projecting sustentaculum tali" (Kocher's "Text-Book of Operative Surgery," translated by Harold J. Stiles).

Disarticulation at the Ankle-joint.—**Syme's Method.**—The foot is held at a right angle to the leg, and a skin-incision is carried, from just below the external malleolus, straight across or a little backward across the sole to a corresponding point on the opposite side. Do not take this incision near to the inner malleolus, as to do so will endanger the posterior tibial artery. The incision is carried to the bone, the flap being pushed back and separated from the bone by means of a strong knife and the thumb-nail until the tuberosity of the os calcis has been reached. The foot is now extended and a transverse cut is made across the dorsum, joining the two ends of the first incision; the ankle-joint is opened, the lateral ligaments are cut, disarticulation is effected, and the foot is finally completely removed by severing the tendo Achillis. A thin piece of bone including both malleoli is sawn from the tibia and fibula. The flap is perforated posteriorly to secure drainage (Fig. 335).

Pirogoff's Method.—Flex the foot to a right angle with the leg. "Make an incision from the tip of the internal malleolus across the sole, a little in front of the long axis of the tibia, to a point in front of the apex of the external malleolus down upon the bone."* Dissect the flap backward from the calcaneum for a quarter of an inch, but do not dissect the flap from the posterior portion of the os calcis. Join the extremities of the first incision by another cut which reaches to the bone, and which is "half an inch in front of the lower extremity of the tibia" (Bryant); but saw off this bony projection obliquely and leave it adherent to the tissues. The saw is used after disarticulation of the ankle-joint; it is passed behind the astragalus, cutting downward and forward, sawing the os calcis obliquely, and leaving a considerable portion in place in the flap. The lower ends of the tibia and fibula are well exposed by raising the anterior flap slightly; the sawing is begun anteriorly just above the articular surface, and is completed half an inch above the articular surface posteriorly. The lines *a* and *b* (Fig. 779) show the sections made by the saw. The sawn surface of the os calcis is brought into contact with the sawn surfaces of the tibia and fibula, and the flaps are sutured.

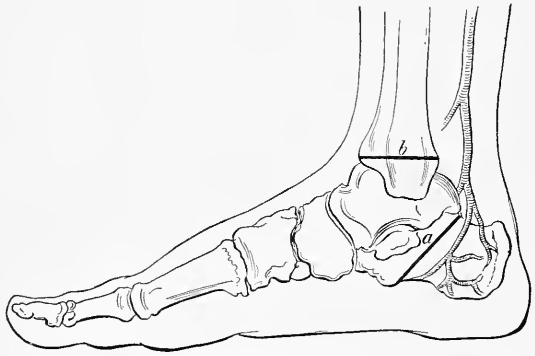


Fig. 779.—Lines of section of the os calcis and the bones of the leg in Pirogoff's amputation.

Amputations of the Leg.—The so-called "point of election" is at the

* "Operative Surgery," by Joseph D. Bryant.

upper part of the middle third of the leg. Seventy years ago Liston advised surgeons not to amputate in the lower third of the leg because of the scantiness of the soft parts, because the stump is apt to ulcerate, and because it is uncomfortable in an artificial leg. These views have been much modified. The amputation near the ankle is safer than the amputation near the knee, and artificial legs are now made which may be worn with comfort. In amputations of the leg by the *long anterior flap*, cut through the skin, dissect up the anterior muscles with the flap, and cut all the posterior tissues with a single transverse sweep. Amputation by the *rectangular flap*, Teale's method, is very useful (see page 1212). The long flap is anterior, and is in length and breadth equal to one-half the circumference of the limb. The short flap is one-fourth the length of the long flap. The flaps are dissected up, the bones are sawn, the long flap is turned upon itself, and its edges are sutured to the edges of the short flap.

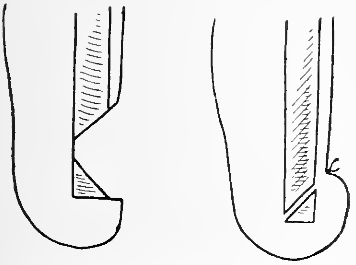


Fig. 780.—Diagrammatic representation of amputation of the leg after the method of Bier.

Bier suggests a plan (Fig. 780) to increase the supporting power of the stump after a leg-amputation. After the wound has healed, a wedge-shaped piece of bone is removed above the level of the stump. The lower extremity is turned forward and upward through an arc of 90 degrees, and unites in this position (Zuckerkandl's "Operative Surgery"). Thus the medullary cavity is closed and the skin which must bear pressure is healthy and free from cicatrices; and as the muscles are still attached to the bone, they do not undergo atrophy.

Sédillot's leg-amputation (Fig. 781) is by a long external flap. A longitudinal incision is made along the inner edge of the tibia, the tissues are drawn toward the fibula, a knife is introduced and passed to the outer edge of the tibia, just touching the fibula, and is brought out posteriorly, thus transfixing the calf-muscles and cutting an external flap. A convex incision is made on the inner side, the bones are cleared and are sawn one inch above the flaps, half an inch more being taken from the fibula than from the tibia, and the tibia being bevelled anteriorly.

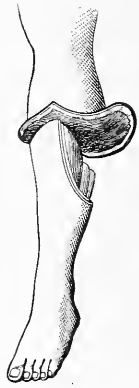


Fig. 781.—Sédillot's amputation of the leg (Wyeth).

Modified Circular Amputation of the Leg.—Cut semilunar skin-flaps, lay them back, and cut circularly to the bone at the edge of the turned-up flap. Another method of modified circular amputation is by adding to the circular cut a vertical incision down the front of the leg. In sawing the bones of the leg the surgeon, who stands to the outer side of the right leg or to the inner side of the left leg, divides the fibula first, and at a higher level than the tibia, and bevels the anterior surface of the tibia. In sawing the left fibula the saw points to the floor; in sawing the right fibula it points to the ceiling.

Amputation of the Leg by a Long Posterior and a Short Anterior

Flap.—In this operation a posterior **U**-shaped flap is made equal in length and breadth to the diameter of the limb. The skin-incision is begun one inch below the point where the bone is to be sawn, and behind the inner edge of the tibia, and is carried to a point posterior to the peronei muscles. The gastrocnemius muscle is divided transversely at the level of the flap, the soft parts on either side in the line of the flap being cut to the bone. Through these vertical cuts the muscles are lifted from the bones and are divided through their lower part by cutting from within outward. The anterior flap is formed by making a semilunar skin-flap and by cutting the muscles across at its retracted edge (Fig. 782).

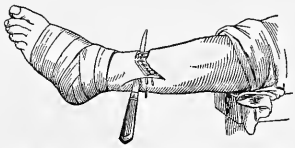


Fig. 782.—Amputation of the leg by a long posterior flap (Gross).

Amputation of the leg by lateral flaps is not a popular operation, as it offers too much encouragement to subsequent protrusion of the bone.

Amputation just below the Knee.—The seat of election is one inch below the tuberosities. No muscle is needed in the flap. Cut two flaps of skin, equal in size and semilunar in shape, these flaps beginning anteriorly two inches below the tuberosity of the tibia. One flap is antero-external and the other is postero-internal. The flaps are pulled up, the anterior muscles are cut as high up as possible, and the posterior muscles are cut through the middle of the portion exposed (Bell). The bone is sawn one inch below the tuberosity.

Disarticulation of the Knee.—In disarticulation by the long anterior flap, make a long anterior skin-flap, incise the ligament of the patella, turn up a flap containing the patella, open the joint, and complete the disarticulation by cutting from within outward and downward. The knee may be disarticulated by means of a long anterior and a short posterior flap. Kocher prefers the oblique incision (Fig. 783). This secures an anterior flap. The leg is so

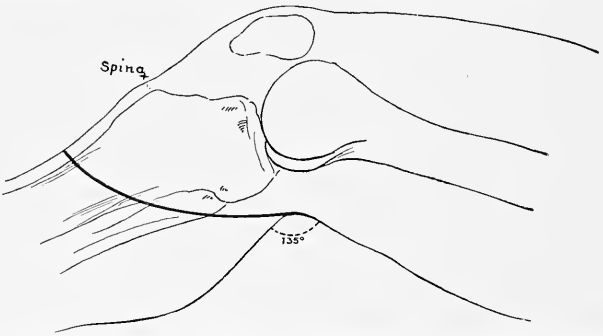


Fig. 783.—Kocher's oblique incision for disarticulation at the knee-joint (Kocher).

held that it makes an angle with the thigh of 135 degrees and "the incision falls in the continuation of the long axis of the thigh" (Kocher's "Text-book of Operative Surgery," translated by Harold J. Stiles). The posterior part of the incision is opposite the line of the joint and the anterior part of the incision ends four finger-breadths below the tibial tubercle.

Amputation through the Femoral Condyles.—*Syme's Method by a*

Long Posterior Flap.—Carry a skin-incision, with a very slight downward curve from one condyle to the other, across the middle of the patella. Cut down to the bone, retract the flap, and cut the quadriceps above the patella. Insert a long knife at one angle of the wound, pass it back of the femur, and make it emerge at the opposite angle, cutting a posterior flap eight inches long. Retract the posterior flap, clear for sawing, and section the condyles horizontally. Carden made a curved section of the condyles at their widest part. In children Buchanan showed that we can easily separate the lower

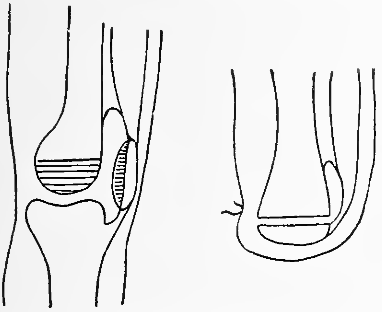


Fig. 784.—Diagrammatic representation of Gritti's operation.

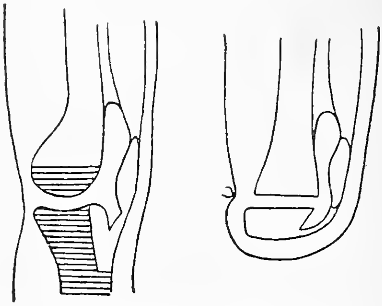


Fig. 785.—Diagrammatic representation of Sabanejeff's operation.

femoral epiphysis. In *Gritti's supracondyloid amputation* an oblique incision is made. The upper end of the incision is posterior and just above the condyles. Its lower end is anterior and two finger-breadths below the patella (Kocher). The ligament of the patella is cut, the flap is turned up, the femur is sawn at the base of the condyles, the articular face of the patella is sawn off, and the sawn patella is fastened to the sawn femur and the flaps are sutured (Fig. 784). Sabanejeff makes an anterior flap, opens the knee-joint from behind, saws the condyles at their broadest part, takes a bone-flap from the anterior portion of the tibia and fastens it to the femur (Fig. 785).

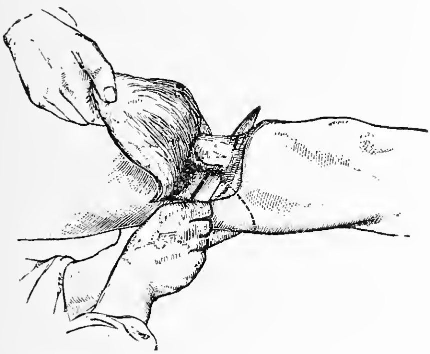


Fig. 786.—Amputation of the thigh (Bryant).

Amputation of the Thigh.—In high amputation in the *lower third* either a flap or a circular operation may be performed. In a double-flap operation a semilunar skin-incision should be made from without inward, and the muscles should be cut by transfixion (Fig. 786). In the lower third Teale's flap or the long anterior flap may be employed. The amputation by a long anterior flap consists in making a lengthy skin-flap, reflecting it, cutting the anterior structures to the bone, again entering the long knife at one angle of the incision, pushing it back of the femur, bringing it out at the outer angle, and cutting the structures behind the bone directly backward. Bell amputates by a long anterior semilunar

flap and a short posterior flap. In amputations in the *upper two-thirds* of the thigh the best plan is to mark out equal anterior and posterior semilunar skin-flaps, divide the skin with a scalpel, enter the long knife at one angle of the anterior flap, bring it out at the other angle, and cut the muscles by transfixion. Cut the posterior flap in the same manner. Some surgeons prefer a long anterior semilunar flap and a short posterior semilunar flap. The pure circular amputation is not adapted to the thigh.

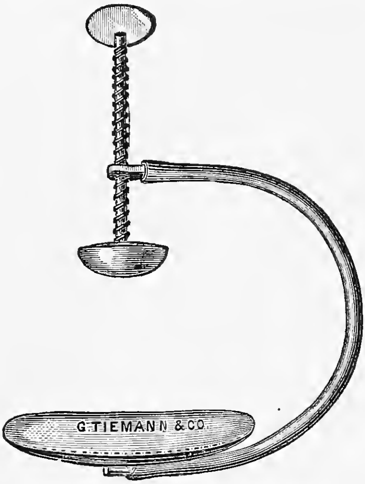


Fig. 787.—Pancoast's aorta tourniquet.

Disarticulation at the Hip-joint.—Various methods have been employed to prevent or limit hemorrhage during this formidable operation. Abernethy used digital compression of the external iliac artery or of the femoral artery. This is an extremely tiresome procedure; the finger is liable to slip; and, in any case, compression so situated fails to intercept the blood-current in a number of large vessels.

Various other methods have been employed. It was formerly the custom to compress the aorta by means of an abdominal compressor (Figs. 787, 789). A tourniquet is very likely to be displaced during the operation. The intention is to compress the artery against the spine, but in effecting this the circulation in a portion of the intestine may be impaired. In any case, as Senn says, the circulation is cut off from half the body, and the patient is exposed to grave danger from "sudden vascular engorgement of important internal organs" (Senn). Again, an abdominal compressor of this sort does not arrest venous bleeding. A number of years ago Davy suggested that a suitable cylindrical piece of wood, about 25 inches long, and shaped like a cone at the end, might be introduced into the rectum and used to compress the common iliac artery upon the pelvic brim. This appliance is known as *Davy's lever.* It is apt to slip, and may do serious damage to the rectum.

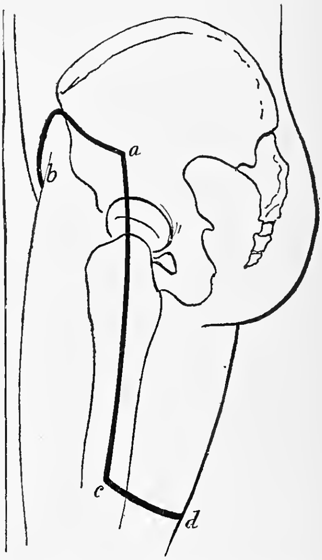


Fig. 788.—Posterior flap in author's unusual case requiring hip-joint amputation. *a*, *b*, The anterior incision; *a*, *c*, *d*, the external incision and the beginning of the posterior cut.

Some surgeons have practised preliminary ligation of the common femoral artery or of the external iliac artery, and others have tied the vessels while making the flaps. I followed this

plan with perfect satisfaction in a recent case of sarcoma of the femur with involvement of the iliac glands. If any form of compression is used, that recommended by Macewen, of Glasgow, is the most successful and satisfactory (Fig. 790). The weight of the assistant's body is thrown upon the patient's aorta by the right fist, placed slightly to the left of the umbilicus. McBurney has suggested the prevention of bleeding by making a small abdominal incision and having an assistant make direct digital pressure upon the iliac artery. I employed McBurney's method in a recent case and found it most satisfactory. In this case a sarcoma of the thigh reached up so far that no band could be applied above it and I was obliged to make the posterior flap shown in Fig. 788. If the constricting band of Esmarch is applied by the ordinary method, it is certain to slip. It may remain in place if applied as a figure of eight of the thigh and the pelvis, but even then it is uncertain.

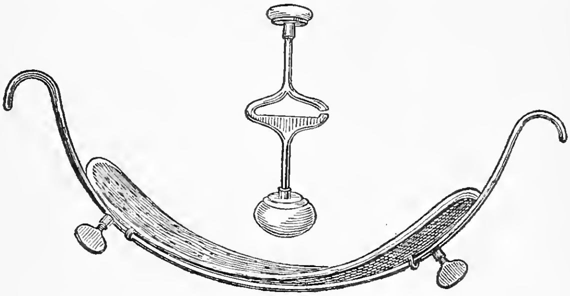


Fig. 789.—Von Esmarch's aorta tourniquet.

Fig. 790.—Macewen's method for compression of the abdominal aorta ("American Text-Book of Surgery").

The most satisfactory method in the great majority of cases, is Wyeth's, in which the constrictor is held in place by the preliminary passage of two steel pins. Trendelenburg's method consisted in passing one pin and winding an elastic tube about it. Wyeth applied the principle and greatly improved the method. The outer pin is inserted an inch and a half below and a little internal to the anterior superior spine of the ilium, and is brought out just back of the great trochanter. The inner pin is entered one inch below the level of the crotch and internal to the saphenous opening, and it emerges an inch and a half in front of the tuberosity of the ischium. A sterile cork is pushed on the end of each pin, to save the surgeon from wounding himself upon the sharp points. After the limb has been emptied of blood by

holding it in a vertical position for five minutes and stroking it from the periphery toward the body, the constricting band is fastened about the limb above the pins.

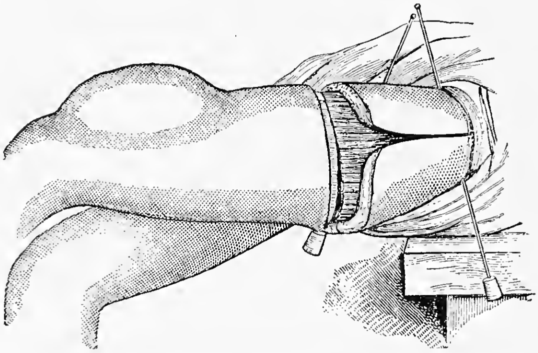


Fig. 791.—Amputation at the hip-joint—Wyeth's bloodless method.

In the *bloodless method of Wyeth* (Figs. 791, 792), after the passage of the pins and the application of the band of the Esmarch apparatus, the amputation is proceeded with. The hip is brought well over the edge

Fig. 792.—Wyeth's bloodless amputation at the hip-joint. Cuff of skin and subcutaneous fat turned back, muscles divided at level of small trochanter, bone partly stripped, and large vessels exposed for deligation.

of the table, a circular incision is made down to the deep fascia, six inches below the constricting band, and is joined by a longitudinal skin-cut reaching from the band to the level of the circular incision, and the cuff is

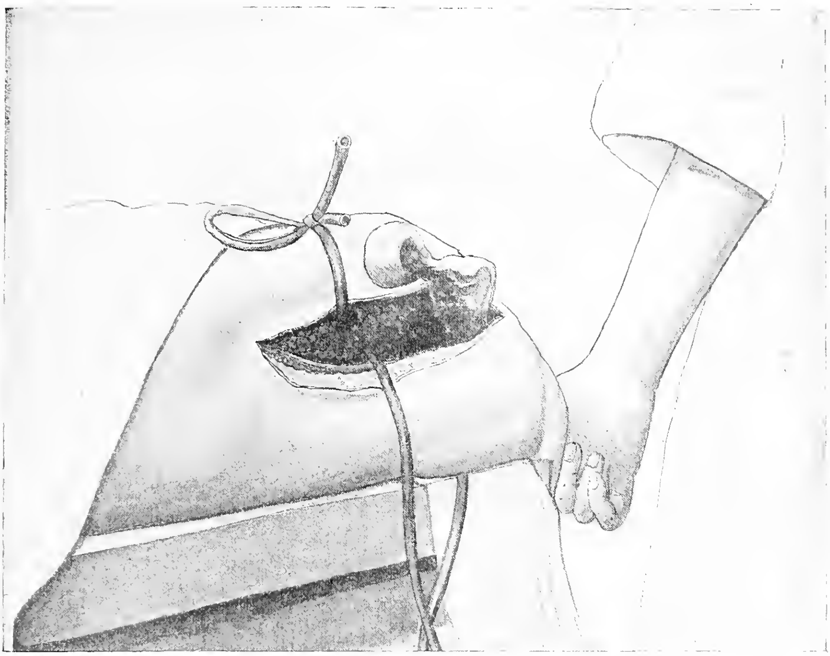


Fig. 793.—Senn's method of performing bloodless amputation at the hip-joint. Dislocation of head of femur and upper portion of shaft through straight external incision. Elastic constrictors in place, the anterior one tied (Senn).

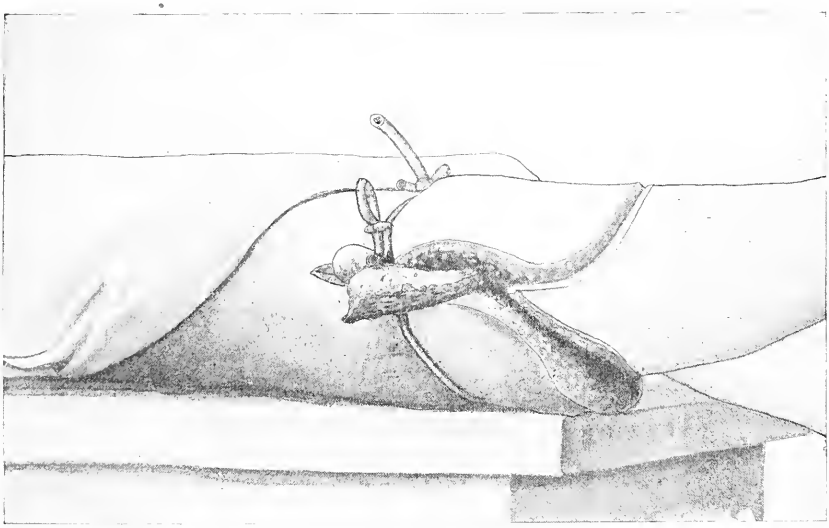


Fig. 794.—Elastic constriction completed by constricting the posterior segment of the thigh. Flaps formed, including all the tissues down to the muscles (Senn).

reflected to the level of the lesser trochanter. The muscles are cut by a circular sweep at the level of the retracted cuff, the capsule of the hip-joint is opened freely, the cotyloid ligament is cut posteriorly, the thigh is bent upward, forward, and inward to dislocate the head of the bone, and, using the thigh as a handle, the round ligament is incised and the limb removed. After ligating the vessels and introducing drainage-tubes the flaps are sewn together vertically. The old transfixion operation is practically extinct. A T-*amputation* may be employed. It consists of an external straight incision down to the bone, starting over the great trochanter, down the outer side of the limb, and a circular incision through the skin five inches below the constricting band, the muscles being cut by a circular sweep at the level of the retracted skin. This method affords easy access to the joint. The bloodless method of Wyeth, as applied to the hip-joint and shoulder-joint, is one of the notable modern advances in the art of surgery.

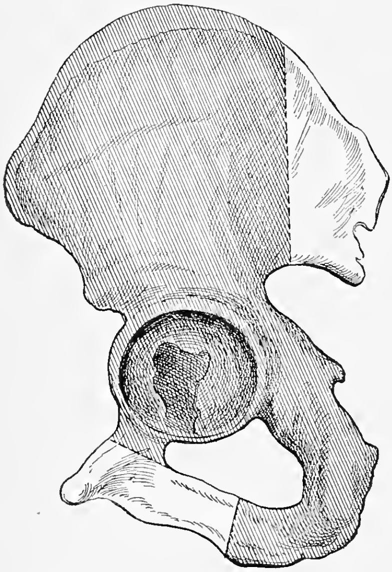


Fig. 795.—Keen and DaCosta's case of inter-ilio-abdominal amputation. The shaded portion of the bone was removed ("International Clinics," vol. iv, 13th series).

Senn's Bloodless Method.—The elder Senn has devised a method for preventing hemorrhage during amputations of the hip-joint. He makes a straight incision, about eight inches in length, in the direction of the long axis of the femur and directly over the center of the great trochanter. This incision reaches about three inches above the upper margin of the great trochanter. The muscular insertions are divided close to the bone, and the thigh is flexed, strongly adducted, and rotated inward. The capsular ligament is divided at its upper and posterior aspect. While the thigh is brought into a position of slight flexion, the remaining portion of the capsular ligament is cut. Then the thigh is dislocated outward, and the ligamentum teres is cut. If this cannot be accomplished, the head of the bone is forcibly dislocated upon the dorsum of the ilium. After dislocating, the lesser trochanter and the upper part of the femoral shaft are cleared. The limb is now brought down in a straight line with the body, the thigh is slightly flexed, a long and stout pair of forceps is inserted into the wound behind the femur and on a level with the normal situation of the lesser trochanter, and the instrument is pushed downward and inward, two inches below the ramus of the ischium and just behind the adductor muscles. As soon as the point can be felt under the skin, an incision two inches in length is made upon it, and the instrument is forced through the opening. The tunnel in the tissues is enlarged by opening the forceps. A piece of rubber tubing three-quarters of an inch in diameter and four feet in length is caught about the middle with the forceps and is with-

drawn. The rubber tube is cut in two at about the point at which the forceps have held it, and half of the tube is used to constrict the anterior segment of the thigh (Fig. 793) and the other half to constrict the remaining portion of the thigh (Fig. 794). Before the constricting bands are tied the limb is held vertically for a sufficient length of time to make it practically bloodless; the amputation is then completed (Senn's "Practical Surgery").

Other Methods.—John G. Sheldon ("Amer. Med.," April 19, 1902) has modified Senn's method as follows: He disarticulates the head of the femur and frees the upper part of the femur from its attachments. He then introduces a pair of long, stout artery-forceps behind the femur and clamps the femoral vessels. He forms the flap, removes the limb, and ligates the vessels. In this operation the surgeon can work rapidly and can make a flap of any size or shape, and is not hindered by a constriction apparatus; but this method does not cut off the bleeding from the obturator and the sciatic arteries.

Larrey amputated by lateral flaps, and Liston by anteroposterior flaps. Forneaux Jordan's method consists in dividing the soft parts low down, tying the blood-vessels on the face of the stump, shelling out the femur from the soft parts, and disarticulating.

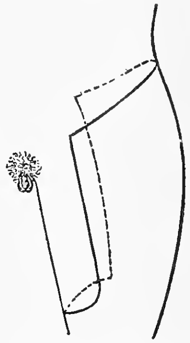


Fig. 796.—Keen and DaCosta's method of interilio-abdominal amputation ("International Clinics," vol. iv, 13th series).

Interilio-abdominal Amputation.—This very formidable operation is occasionally performed for sarcoma of the ilium. The operation was first performed by Billroth in 1891, and the patient died. Dr. Keen and I collected 19 cases, including 1 of our own. Five of these cases recovered (W. W. Keen and J. Chalmers DaCosta, in "International Clinics," vol. iv, 13th series). Our patient perished in thirty-three hours from suppression of urine and with gangrene of the parts supplied by the internal iliac artery. In some cases the entire innominate bone has been removed, in others portions of it have been left. In our case we made the flap shown in Fig. 796, tied the internal iliac artery after rolling up the peritoneum, but spared the external iliac, kept the femoral in the flap, and sawed through the bones as indicated in Fig. 795, leaving in place the portions shown in white.

XXXVIII. DISEASES OF THE MAMMARY GLAND.

Hypertrophy of the Breast (Fig. 797).—This is a rare condition. It may affect one breast or both. It is most apt to appear at the age of puberty, but it may appear in childhood, adult life, or old age. The breast may attain enormous size. In Porter's case the breasts of a woman of thirty-seven were so very large that they were carried hung upon a frame ("Boston Med. and Surg. Jour.," March 3, 1892).

These very large breasts are not composed of true gland tissue, but rather of fat and connective tissue (Sheild). Hypertrophy may also occur in the male breast. In some cases hypertrophy occurs so rapidly as to merit the name acute. Such cases may perhaps be sarcomatous.

Treatment.—Be sure it is hypertrophy and not sarcoma, adenoma, or lipoma. Try recumbent posture, dry diet, pressure, and iodid of potash (Sheild). If these means fail, amputation is the only resource.

Mammillitis and Fissure.—The nipple may inflame as a result of injury, but the condition is rarely encountered except in a woman who is nursing a baby. It is most common after a first pregnancy, when the nipple is deformed or when the skin is delicate. The nipple is slightly injured during nursing, and the epithelium is macerated by the milk and saliva. If the inflammation is not arrested, a spot excoriates or an irritable ulcer forms (a fissure). A fissure is often surrounded by an area of acute inflammation, and nursing causes intense agony. Because of the pain the mother is apt to extend the intervals between nursing, and as a consequence the breasts become swollen with retained milk. The ulcer not unusually bleeds when the breast is taken by the child. Besides the facts that a fissure causes pain to the mother, it often leads to grave trouble. It is a suppurating area, and as such may lead to abscess of the mother's breast, or may impair the health of the nursing child.

Fig. 797.—Hypertrophy of breast (Horwitz).

Prevention of Fissure.—During pregnancy the nipples should be carefully attended to. They should be washed often in sterile water and bathed in alcohol, and if retracted, ought to be drawn out repeatedly. During the period of lactation the nipples are washed in sterile water, dried, and dusted with borated talc powder as soon as an act of nursing is completed. Washing the nipples regularly with the following solution tends to prevent the formation of a fissure: iodid of mercury, gr. ij; alcohol, ℥iss; glycerin and distilled water, āā a pint (Lepage). If a small abrasion appears, order the woman to wear a nipple-shield during nursing, and after each act of nursing to wash the part with hot sterile water, dry, and dust borated talc over the surface. If a fissure forms, wean the child at once, and dry up the milk in both breasts. It is useless to try and dry it up in one breast. Milk may be dried up by applying ointment of belladonna locally, and administering iodid of potassium internally; by strapping the breasts with adhesive plaster (Parker); or by applying to the nipples six times a day a 5 per cent. solution of cocain in equal parts of glycerin and water (Joise). The fissure is not treated by ointments.

These preparations are septic, prevent drainage, and aggravate maceration. Wash the fissure twice a day with peroxid of hydrogen, dress it with gauze wet in boric-acid solution (gr. x to ℥j of water), and cover the dressing with waxed paper. If the fissure resists treatment, touch it with lunar caustic.

Acute Mastitis and Abscess.—Acute inflammation of the breast, as a result of injury of the breast or nipple, may occur in either sex at any time of life. Very commonly in both sexes a few days after birth the breast becomes distended with a material which in reality is milk. The fluid is usually small in quantity. The process is physiological, and, as a rule, ceases spontaneously (Guelliot). If it lingers, the application of belladonna ointment will stop secretion. If the nurse meddles with and tries to squeeze out the fluid, acute mastitis is apt to arise in one gland, or occasionally in both. The skin of the breast reddens, the gland swells and becomes tender and painful, the child loses its appetite and becomes feverish, restless, and sleepless. Such a condition is treated by the local use of lead-water and laudanum. If pus forms, the local signs and constitutional symptoms are aggravated. Evacuate the pus, dress with hot antiseptic fomentations, and be sure that the child is well nourished. Tonics and stimulants are indicated.

A condition identical with the secretory activity of the glands of the newborn may occur in either sex at puberty. The methods of treatment are the same in both cases. As a matter of fact, rarely more than one lobule at this period inflames, and suppuration is most unusual.

Mastitis is most usually met with in a woman who is nursing a child, and is due to bacterial infection. Primipara are particularly liable to develop mastitis. So are women with deformed nipples. In many cases an abrasion of the nipple exists, and through this breach of continuity bacteria gain entrance to the breast-tissue. The abrasion may be so slight that it can only be detected when the nipple is examined through a magnifying-glass (Marmaduke Sheild). Streptococcic infections are very generally due to inoculation of a fissure of the nipple. Bacteria may pass up the milk-ducts, coagulating the milk and penetrating through the walls of the acini. Staphylococci not unusually pursue this route in reaching the breast-tissue. Occasionally causative bacteria reach the breast through the arteries (in septicemia and in septic wounds of the genital organs).

Symptoms.—There are pain, swelling, and tenderness in the breast, and in most cases a fissure or abrasion exists. There is a febrile condition. Occasionally a chill ushers in the attack.

Treatment.—Order the patient to suspend nursing. The physician endeavors to arrest the secretion of milk. Treat the nipple as advised on page 1228. Support the breast and apply ichthyol ointment or lead-water and laudanum.

Mastitis may undergo resolution; it may terminate in organization and induration; it may eventuate in suppuration.

Acute abscess of the breast follows acute mastitis. There may be but one area of suppuration, or multiple foci may exist, which eventually fuse. The symptoms of mastitis, local and constitutional, are greatly aggravated. After a time the skin becomes dusky and edematous. The axillary and superficial cervical glands enlarge. The abscess will eventually open spontaneously at one or more points, leaving branching fistulæ. A super-

ficial abscess is situated just beneath the nipple, and pus may flow from the nipple.

An intramammary abscess is in the depths of the gland. There are often multiple foci of suppuration. Nodules are felt in the gland, pus may run from the nipple, but cutaneous redness is late in appearing.

Retromammary abscess is a rather rare condition. It may occur alone or be associated and connected with an area of intramammary suppuration. It may result from metastasis or from caries of a rib. The breast is lifted up by the fluid beneath it.

Treatment.—Open a superficial abscess by an incision radiating from the nipple. Treat as any other acute abscess. An intramammary abscess should be opened by a radiating incision, and pockets of pus should be broken into with the finger. An examination is made to determine if a retromammary abscess also exists. If this is found to be the case, an incision is made at the point of junction of the thorax and mammary gland, and at the lower border of the gland. The gland is raised from the chest-wall, the pus evacuated, a drainage-tube is inserted, and a few sutures are introduced. If retromammary abscess exists alone, make the last-named incision in the first place.

Chronic Mastitis.—This condition may be present in only a portion of the breast, or may attack many lobules (lobular mastitis). The ordinary form may arise after weaning a child, or may be due to a blow, to the pressure of corsets, or to numerous slight traumatisms. It may occur in the young, the middle aged, or the old. The patient has slight pain at times in the gland. Examination detects a firm, elastic area, which is somewhat tender and does not possess distinct margins. The skin is not adherent to the mass unless suppuration occurs. If the mass is pressed against the chest by the surgeon's fingers, it becomes evident that no real tumor exists.

Treatment.—Remove any cause of irritation. Support the breast in a sling. Apply ichthyol ointment. During the night employ a hot-water bag. If pus forms, treat as before directed.

Chronic lobular mastitis is a condition in which numerous lobules become indurated. The real cause of this condition is unknown. It may occur at any age after puberty, and often attacks both breasts. Such a breast is apt to be painful, especially at the menstrual periods; it feels unnatural, solid, and careful examination detects numerous indurated areas, each of which is of small size. At the menstrual period the breast enlarges and new nodules may be detected. In some of these cases violent neuralgic pains are present in the gland (mastodynia). Chronic lobular mastitis is apt to lead to cyst-formation. When cysts form fluid may occasionally discharge from the nipple.

Treatment.—Support the breast and apply ichthyol ointment or belladonna ointment. Examine the generative organs and correct any existing abnormality. Improve the general health by good food, tonics, and open-air life. In cases where multiple cysts are known to exist the question of treatment is uncertain. There seems to be little doubt that such cases tend in some instances to eventuate in cancer. I believe that the proper treatment when multiple cysts exist is extirpation of the breast.

Tuberculosis of the Mammary Gland.—(See page 152.)

Cysts and Tumors of the Nipple.—**Tumors** are rare in the nipple,

but do sometimes occur. The following growths are occasionally seen: fibroma, angeioma, papilloma, myxoma, myoma, and epithelioma. Sebaceous cysts of the nipple and areola are not very unusual. A cancer of the nipple may be a primary growth, or may be secondary to gland cancer. Primary epithelioma of the nipple presents the same general characters as epithelioma in any other region. It begins as an indurated area in the areola, or an excoriation of the nipple. Ulceration soon occurs. The ulcer is irregular in outline, has hard edges, and furnishes a foul, red, sanious, and fetid discharge. The mammary gland becomes infiltrated at an early period. The subclavian glands enlarge, and later the axillary glands. Such a growth must not be confounded with a chancre of the nipple.

Treatment of Tumors of the Nipple.—Innocent tumors are to be excised and the breast need not be removed.

Epithelioma of the nipple requires the complete extirpation of the breast, and also the clearing out of the lymphatic contents of the axilla, and possibly of the subclavian triangle.

Paget's Disease of the Nipple (Malignant Dermatitis).—This condition is a chronic inflammation of the epithelial layer of the nipple and areola occurring in women beyond middle life, and is a not unusual precursor of epithelioma of the nipple and of duct cancer. Paget's disease is not a simple eczema, it is not associated with the usual causes and attendants of eczema, either local or constitutional, and is not cured by remedies which control the ordinary disease.

The diseased area is raw and red, and from it exudes copiously a thick, yellow discharge. In some cases Paget's disease is secondary to duct cancer, auto-infection of the nipple having been effected by the fluid flowing from the ducts. Investigations have shown the presence of psorosperms in areas of Paget's disease.

Treatment consists in removal of the entire breast and clearing out of the axilla and subclavian triangle.

Tumors and Cysts of the Mammary Gland.—These tumors may be innocent or malignant.

Innocent Tumors of the Mammary Gland.—The innocent tumors are: *Fibro-adenomata or cystic adenomata, myxomata, villous papillomata, and angiomata.* It is maintained by most authorities that any innocent tumor of the gland may and often does become malignant.

Fibro-adenoma.—The nomenclature of fibro-adenomata is in a state of great confusion. The name fibro-adenoma was given by Cornil and Ranvier to the same sort of growth which the younger Gross called a fibroma, Billroth an adeno-fibroma, and Sir Astley Cooper a chronic mammary tumor. It is doubtful if a pure fibroma ever occurs in the mammary gland. A fibro-adenoma consists of acini surrounded by fibrous tissue. Each of these structures proliferates, but the fibrous tissue does so much more rapidly than the glandular. A growth of this character is surrounded by a capsule, and is movable. It is firm, elastic, lobulated, superficially situated, and of slow growth. It is unassociated with retracted nipple, glandular enlargement, adhesion to the skin, or cachexia, and may occur at any age up to fifty, but is most common between twenty and thirty (J. Bland Sutton). Such a tumor is rarely very painful, but it may be tender on rough handling and

may be painful at the menstrual period. As a rule, there is but one of these tumors in a mammary gland, but one may exist in each gland.

Treatment.—Extirpation of the tumor.

Cystic adenoma (**adenocele**) is a rare form of slowly growing tumor, which is apt to attain a large size, which is nodular in outline, hard to the touch, and firmly attached to the mammary gland, but mobile upon the chest. A cystic adenoma has a distinct capsule. This form of tumor is painless, and is most apt to occur in women between thirty and forty who have borne children. The growth is adherent to the skin, but the cutaneous surface is not discolored, the cutaneous veins are not distended, the axillary glands are not enlarged, and the nipple is not retracted. From the walls of the dilated acini papillomatous growths are apt to arise (intracystic vegetations).

Treatment.—Removal of the breast.

Myxoma is a rare tumor, and only occurs in a person of middle age. The growth is solitary, is soft, may be round or lobulated, and occasionally fungates. The nipple is not retracted, the superficial veins are not distended, and the axillary glands are not enlarged.

Treatment.—Removal of the mammary gland.

Angioma.—This form of tumor is very rare. It may arise secondarily to a nevus of the skin (Sutton). The diagnosis of angioma of the skin is readily made. In a cavernous angioma of the breast it will be found that the tumor can be lessened in size by pressure, and will be increased in size by coughing, laughing, and holding the breath. Pulsation may be detected and a bruit may be audible.

Treatment.—For treatment of nevus see page 314. If a cavernous angioma exists in the mammary gland, it will be necessary to extirpate the gland.

Cysts of the Mammary Gland.—**Involution cysts** (cystic degeneration of the mamma) occur in women who are approaching the menopause. They occur earlier in those who are sterile than in those who have borne children, and may arise after chronic mastitis. The parenchyma of the gland undergoes atrophic change, but the ducts remain, become blocked and dilated. Numerous small cysts form, and both glands, as a rule, suffer. Villous growths may arise in the walls of the ducts. In some cases there is much white fibrous tissue between the cysts (cystic fibroma).

The subjects of this disease are often nervous, hysterical, and despondent. One or more ill-defined indurations are detected. Frequently there is a history of discharge from the nipple and of attacks of lancinating pain in the breast. Cystic breasts are dangerous, because the intracystic vegetations are liable to eventuate in duct cancer.

Treatment.—In such cases, after confirming the diagnosis by an exploratory incision, remove the entire breast (Snow).

Lacteal cyst (**galactocele**) is an accumulation of milk brought about by blocking of some of the milk-ducts. It arises soon after the delivery of the child, and grows rapidly. A large quantity of milk may collect, and rupture of the cyst-walls can occur, the fluid passing into the glandular connective tissue.

A galactocele is rounded, fluctuates distinctly, and increases in size during

nursing. There is little or no pain. In some cases the contents of the cyst coagulate and a solid mass is formed.

Treatment.—Incision and drainage.

Hydatid cysts are rare, but do occasionally occur. There are 33 positive cases on record (Le Conte, in "Amer. Jour. Med. Sciences," Sept., 1901). A small, hard, movable, and painless mass appears in the mammary gland. Usually it gradually increases in size, but it may grow rapidly for a time and then remain apparently almost stationary for a period. If rapid growth takes place there is always pain, and pain is usual in any case when the cyst attains considerable size. Fluctuation is often absent and crepitation is never obtained (Le Conte). Suppuration is apt to occur and sinuses may form.

Treatment.—A small and recent cyst may be extirpated. If the cyst is not recent, but is fairly large and adherent, incise, evacuate, and pack with gauze. If the cyst is large and adherent, but is surrounded by considerable breast-tissue, partially amputate the breast (Le Conte). If the cyst is large and the breast practically destroyed, or if the nipple adheres to the cyst, remove the mammary gland (Le Conte).

Malignant tumors of the mammary gland are ten times more common than innocent tumors.

Sarcoma.—Sarcoma of the mammary gland is a very rare growth (less than 10 per cent. of breast tumors). It may occur at any age from puberty to old age, but is most common from twenty to thirty-five. The growth may be composed of round cells or spindle cells; both varieties may be present, and myeloid cells may be found. Circumscribed sarcoma arises usually between the ages of twenty and thirty; it is firm to the touch, as it contains much fibrous tissue, is painless, does not grow very rapidly, glands are not involved, and there is no cachexia. The nipple is not retracted. The growth may adhere to the skin. It is composed of giant cells or spindle cells, and rarely returns after extirpation of the breast.

Diffused sarcoma is composed of small round cells, arises in the center of the breast, and grows with great rapidity. It is most commonly met with about the age of thirty-five, and a history of injury can often be elicited. The tumor is soft, some parts being softer than others because of cyst-formation. It is usually mobile upon the thorax, though it soon becomes adherent to the skin. The tumor reaches a very great size, and soon fungates through the skin. There is little or no pain. The cutaneous veins over the tumor are distended, the nipple is not retracted, and the axillary glands are not often enlarged. Diffuse sarcoma is apt to recur after removal.

Treatment.—Remove the breast, and if the muscles of the chest-wall are infiltrated, remove them. The axillary glands are removed if they are enlarged, but not otherwise. Operation will not cure when metastases exist. If the case is inoperable, we can try the use of Coley's fluid. If the toxins of erysipelas fail to arrest the progress of the disease, keep the patient as comfortable as possible by the administration of cocain and morphin.

Carcinoma or Cancer of the Mammary Gland (Fig. 798).—The great majority of mammary tumors belong to the genus carcinoma. Cancer is due to proliferation of the epithelium of the acini (acinous cancer) or of the ducts (duct cancer).

Acinous cancer is vastly more common than duct cancer. Usually there

is much connective tissue and but little parenchyma in the growth (scirrhus cancer). In some cases there is little connective tissue and much parenchyma (encephaloid or medullary cancer). If colloid degeneration of the parenchyma or stroma occurs, the growth is spoken of as colloid cancer.

Scirrhus, the common form of acinous cancer, is almost as hard as stone. On section it is concave, and Sutton says "resembles an unripe pear." The tumor is without a capsule, and the epithelial cells are surrounded by masses of fibrous tissue. Portions of tissue, even some distance away from the

Fig. 798.—Scirrhus carcinoma (J. Collins Warren).

tumor, contain foci of proliferating embryonic epithelial cells. In atrophic or withering scirrhus the fibrous stroma contracts and epithelial cells undergo fatty degeneration (Senn).

Causes and Symptoms.—Scirrhus is more common among women who have borne children than among those who have not. Heredity is manifest in only about 10 per cent. of cases (Bryant). The younger Gross found it in 1 case out of 9. Trauma has no apparent influence in producing cancer. The disease is rare before the age of thirty-five, and is most common between forty-five and fifty. The author operated for scirrhus of the breast on a

woman only twenty-seven years of age. Henry saw a woman of twenty-one with cancer. It is frequently met with in the aged. These tumors are rare in the negro race. A hard nodule is found in the breast, usually under the nipple, but possibly far away from it. The growth is nodular, and is immobile from the beginning. In a large, fat breast there is often a deceptive sense of mobility, because some of the breast-tissue moves with the tumor. The cancer may have been present for a considerable time before being discovered. Sometimes wide-spread lesions develop from a small or an undiscovered breast cancer (pleural effusion, enlarged glands of the neck, disease of the spinal cord, bones of skull and brain). In obscure lesions of bones and viscera examine the mammary glands, because the trouble might be due to metastasis from an undiscovered carcinoma of the breast. What Osler calls *mastitis carcinomata* is a wide-spread regional metastasis, affecting one or both breasts and beyond them, and which attains a considerable size in a very few months. The breast soon becomes enormous and brawny, the skin is infiltrated, there are no nodules, the glands above the clavicle usually enlarge, and the arm may swell (Osler, Volkmann, and Charbonnier). Metastases may occur within the chest, either by lymph regurgitation from the axillary and subclavian glands, or directly through the chest walls to pleura and lung or to mediastinal glands. Retraction of the nipple is present in over one-half of the cases (S. W. Gross). It occurs when the growth is near the nipple, and is due to the contracting fibrous tissues of the tumor pulling on the milk-ducts. If the growth is far away from the nipple, a dimple is apt to form on the skin of the breast because of the pulling upon the suspensory fibers.

Glandular enlargement in the axilla soon follows the appearance of a scirrhus; the glands become very hard and adherent. In over 60 per cent. of persons the glands of the axilla are felt to be enlarged when the patient first comes for treatment. Because the surgeon cannot feel enlarged glands is no proof that there are none. As a matter of fact, the glands are usually involved within two months of the beginning of the disease, but the involvement can rarely be detected externally until months later. Enlargement of the axillary glands is followed by enlargement of the glands in the posterior cervical triangle and in the mediastinum. Herbert Snow has shown that the blocking of the axillary glands often leads to regurgitation of lymph containing cancer-cells, the cells being thus deposited in the head of the humerus and the thymus gland. Cells in the thymus, after a time, cause a projection of the sternum (the *sternal symptom*). When the axillary lymphatics are extensively involved, the arm swells from obstruction to the lymph-flow (lymph-edema) or pressure upon the vein. The tumor usually grows rather slowly unless lactation is established; then it grows rapidly. As it grows it infiltrates adjacent structures (the pectoral fascia, pectoral muscles, subcutaneous cellular tissue, and skin). When the skin is destroyed, an ulcer forms, and around this ulcer the skin becomes red and filled with cancerous nodules, which feel like shot in the skin. Metastases are apt to occur into the bones, liver, brain, pleura, spine, thymus gland, and rarely the eye.

Pain is usually present in scirrhus carcinoma. It is lancinating and neuralgic in character, and not brought on or increased by handling. It ceases if colloid degeneration begins. The general health is usually unimpaired until ulceration takes place, when cachexia arises. The *cancer en*

cuirasse of Velpeau is a condition in which the lymphatic vessels of the skin are extensively invaded, the growth itself being adherent to the wall of the thorax. In this condition the chest-wall is fixed, respiration is difficult, and the temperature is commonly somewhat elevated.

In *atrophic* or *withering scirrhus* the contraction is so great that it seems as though the mammary gland had been removed. The duration of scirrhus, when left to run its course, varies, but the disease generally produces death within two and a half years. Occasionally it causes death within a year. In atrophic scirrhus the patient may live for many years.

Duct cancer is not a common growth. It arises from the duct-walls in conditions of cystic degeneration of the mammary gland. The tumor is softer than the acinous growth, and is not nodular. There is no pain, no retraction of the nipple, no skin dimple. Serous or bloody fluid may often be squeezed from the nipple. A duct cancer grows and infiltrates less rapidly, and involves adjacent glands later than does an acinous growth.

Cancer of the Male Breast.—This condition is seldom met with, though I believe it to be more common than is generally supposed. I have seen two cases within the last ten years. Each patient was in the early forties; neither complained of pain. In one, the breast had been extremely large from early years. In each case the growth was indurated, but in neither was there any retraction of the nipple. The condition in each patient was scirrhus carcinoma. Warfield has collected 32 cases from literature and has added 5 others ("Bull. of Johns Hopkins Hosp.," Oct., 1901). The patients were between forty and seventy years of age. Eight gave a history of injury; in 9 cases there was pain, and in 12 the nipple was retracted.

Treatment of Carcinoma of the Mammary Gland.—The treatment is early and thorough operation; the earlier and the more thorough, the better. The older surgeons operated simply to prolong life a few months; the modern surgeon operates with the hope of curing the patient. In 1878 Billroth's statistics showed only 8 cures in 143 cases. In 1896 W. Watson Cheyne reported 12 cures out of 21 cases (57 per cent.). His cases now show 54.8 per cent. alive and well from six to thirteen years after operation. The operation should remove the breast and much of the skin above it, the pectoral fascia, and often the pectoral muscles; the fat and glands of the axilla, the fat and glands of the subclavian triangle, and the fascia over the serratus magnus. As Cheyne says, remove all the glands along the axillary vein and lift up the vein at the apex of the axilla and remove the glands and fat behind it. The sheath of the vein should always be removed. Cheyne points out that the line of spread must be traced upward along the vessels and nerves and downward along the external respiratory nerve of Bell ("Lancet," March 12, 1904). If three years after an operation there has been no return, we regard the case as cured (Volkmann's limit). As a matter of fact, recurrences are noted after five years, and this limit should be used instead of three years. Certain cases are unsuited for a radical operation: cases in which metastases exist; cases of *cancer en cuirasse;* cases where axillary involvement is very great. Cheyne would also rule out cases where large glands may be felt above the clavicle, believing that in such cases the mediastinal glands must be cancerous.*

Halsted's Operation.—Halsted performs a very radical operation. He

* See "Objects and Limits of Operation for Cancer," by W. Watson Cheyne.

removes suspected tissue *in one piece*, and thus prevents carcinoma cells falling in the wound, for it is well known that if such cells should fall into the wound, they may grow just as may a graft of healthy epithelium. The neck, shoulder, the arm to the elbow, the entire surface of the chest down to the

Fig. 799.—Halsted's operation for carcinoma of the breast; the first incision.

waist, both breasts, the axilla, the side and the back of the diseased side must be sterilized. It is necessary to have, besides scalpels and the ordinary instruments for an operation, a great number of hemostatic forceps (80 to 100). Place the patient recumbent, with a sand-pillow under the shoulder of the affected side. The shoulder is right at the edge of the bed, and a nurse holds

Fig. 800.—Halsted's operation for carcinoma of the breast; the mass turned down.

the arm from the side. Halsted describes his operation as follows:* The skin-incision is made as shown in Fig. 799, and is carried at once through the fat. The triangular skin-flap (*a*, *b*, *c*) is turned down. The costal insertions of the great pectoral muscle and the muscle are split between the clavicle and

* Johns Hopkins Hosp. Reports, vol. iv; Annals of Surgery, Nov., 1894.

costal portions and up to a point opposite to the scalene tubercle, and at this point the clavicular portion of the muscle and the tissue overlying it are cut through close to the clavicle, and the apex of the axilla is at once exposed. The cellular tissue under the clavicular portion of the muscle is dissected from the muscle, and the splitting of the muscle is continued on to the humerus. The part of the muscle to be removed is cut through close to its humeral insertion. The whole mass circumscribed by the first incision (skin, breast, areolar tissue, and fat) is raised with considerable force in order to put the submuscular fascia on the stretch as it is stripped from the thorax close to the ribs. It is well to include the delicate sheath of the pectoralis minor muscle. The lower and outer boundary of the lesser pectoral having been passed and exposed, the muscle is cut at a right angle to its fibers and a little below the middle. The tissue over the pectoralis minor muscle near its coracoid insertion is divided as far out as possible, and is then reflected inward to prepare for the reflection upward of this part of the minor muscle. The upper portion of the minor muscle is retracted upward. Some surgeons do not remove the lesser pectoral muscle. I believe it should be removed, because the axilla can then be more easily and rapidly cleared. The removal of the muscle does not impair arm movements, and its retention leads to the formation, when healing is complete, of a cord-like band in front of the axilla. (See Douglas Drew, in "Brit. Med. Jour.," May 17, 1902.) The small blood-vessels under the minor muscle are carefully separated from it, are dissected out very clear, and are ligated close to the axillary vessels. Having exposed the subclavian vein at the highest possible point below the clavicle, the contents of the axilla are dissected away with a sharp knife and the vein and its branches are stripped absolutely clean. The loose tissue about the artery and the nerves should also be removed. When the vessels are cleared, the axillary contents are rapidly stripped from the inner walls of the axilla and the lateral wall of the thorax (Fig. 800). The fascia which binds the mass to the chest is cut close to the ribs and the serratus magnus muscle. Just before reaching the junction of the posterior and lateral walls of the axilla an assistant draws the triangular flap of skin outward in order to spread out the tissue which lies upon the subscapularis, teres major, and latissimus dorsi muscles. The operator cleans the posterior wall of the axilla from within outward. The subscapular vessels are clearly exposed, and are caught before they are cut. In some cases the subscapular nerves are removed, in others they are permitted to remain. Having passed these nerves, the mass is turned back into its normal position and severed from the body of the patient by a stroke of the knife from *b* to *c*, repeating the first cut through the skin. Every bleeding point, however small, is tied with fine silk. From 60 to 100 ligatures or even more may be required.

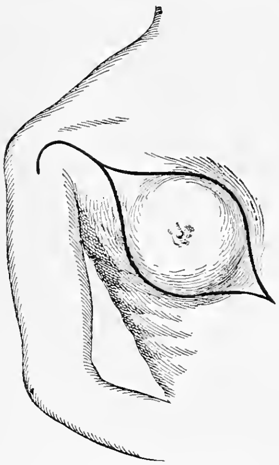


Fig. 801.—The younger Senn's incision for amputation of the breast.

After the completion of the operation the wound into the axilla is closed

with a subcuticular stitch of silver wire; if a cut has been carried above the clavicle, it is closed in the same manner, and the edges of the elliptical opening are brought nearer together by a purse-string subcuticular stitch. Thiersch grafts cut from the patient's thigh are used to cover the gap. Silver-foil is placed over the wound, this is covered with gauze, bandages are applied, and the dressing is overlaid by a plaster-of-Paris bandage, which includes the head, neck, chest, and arm. The area from which grafts were taken is dressed with sterile gauze or an ointment containing boric acid.

Formerly I did not open the subclavian triangle. I believed that these glands were involved only from the axillary lymphatics, that when they were involved the mediastinal glands were sure to be affected (the route to them being more direct) and operation was certain to be useless. When the sub-

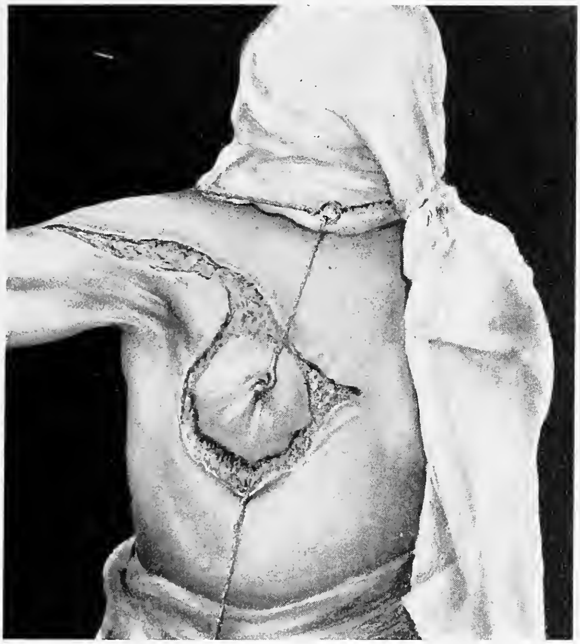


Fig. 802.—Willy Meyer's operation for carcinoma of the breast. Skin incision as practised since 1898.

clavian glands are involved from the axillary lymphatics this is true, but in some cases they are involved by way of the direct lymph paths from the mammary gland. In such a case the mediastinal glands may be free, and cleaning out the subclavian triangle may save the patient. I always open the subclavian triangle and clear out fat and glands if no glands or only a few small glands were palpable before operation. If there is a large glandular mass in the triangle, operation is useless.

The Younger Senn's Incision.—A very useful incision is that described by the younger Senn, and shown in Fig. 801. The breast is circumscribed by two curvilinear incisions which meet above, at the border of the great pectoral muscle. The incision is continued a little internal to the outer border of the muscle to about one inch above the apex of the axilla, when it is curved

outward in the deltoid region, and terminates at the level of the apex of the axilla. The breast is removed from the wall of the chest, and is then suspended by axillary glands and fat, which are removed *en masse*.* This incision gives a free exposure, opens the axilla from in front, enables the surgeon quickly to locate and freely expose the axillary vein, and the resulting scar does not limit materially the motions of the arm.

Willy Meyer's Operation ("Jour. Amer. Med. Assoc.," July 29, 1905).—For the last year I have been performing the operation devised by Willy Meyer. I consider it a most excellent procedure, with distinct points of superiority over other plans. Two flaps are formed by the skin-incision (Fig. 802)—a

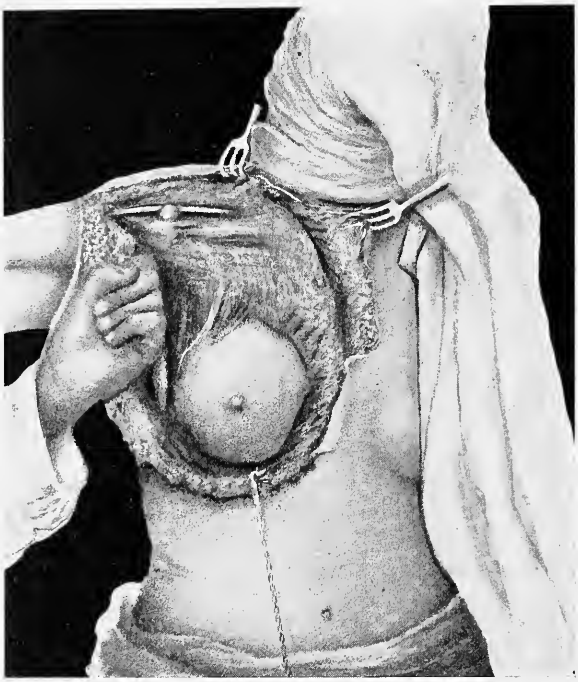


Fig. 803.—Willy Meyer's operation for carcinoma of the breast. Insertion of pectoralis major muscle exposed. Operator's left index-finger encircling its tendon.

lower and an upper flap. The incision for the formation of the lower flap begins at the point of insertion of the great pectoral muscle on the humerus, and is carried downward and inward half an inch above the border of the muscle and parallel to it. When the incision reaches the base of the mammary gland, it is carried along the lower margin of the gland, and it ends over the sternum, a little beyond the mid-line (Fig. 802). The lower flap is separated and turned down, a quantity of subcutaneous fat being allowed to remain attached to the breast. This turning down is carried to the border of the latissimus dorsi muscle, to the axillary cavity, and to the chest-wall. Meyer then directs that the border of the latissimus dorsi be followed down to the serratus anticus

* See the younger Senn in Jour. Amer. Med. Assoc., May 27, 1899.

major, and upward to the mass of fat that enters the bicipital sulcus of the arm. The fat is removed from the anterior border of the muscle by blunt dissection. This anterior lower wound is then packed with gauze.

The surgeon next forms the upper flap by uniting the inner and outer ends of the first incision with another incision carried along the upper margin of the breast (Fig. 802). In this flap, as in the other, the surgeon leaves as much subcutaneous fat adhering to the breast as he can spare without inducing the danger of skin-necrosis. This upper flap is raised progressively until the cephalic vein is reached and there is exposure of the lower surface of the clavicle with the sternoclavicular articulation. Meyer directs that the tissues covering this articulation shall not be disturbed.

Fig. 804.—Willy Meyer's operation for carcinoma of the breast. Finger under tendon of pectoralis minor muscle. Above, cut surface of clavicular portion of pectoralis major parallel to clavicle is visible (in the living, the belly of the pectoralis major is not so thoroughly detached from that of the pectoralis minor. It is done here to show the latter's tendon).

After the formation of these two flaps the next step in the operation is the division of the tendons of the two pectoral muscles and the exposure of the axillary and subclavian veins. Meyer advises that the cephalic vein be followed up until the insertion of the great pectoral muscle into the humerus is found. The tendon is fully exposed, care being taken to bare it of axillary fat. The arm is then carried a little nearer to the side to relax the great pectoral muscle. This tendon is cut off close to the humerus (Fig. 803). The muscle is pulled downward and inward and is loosened from the cephalic vein. It is then cut off near the lower border of the clavicle and the sternoclavicular articulation. It is necessary to divide the nerves that enter the pec-

toral muscle, and all the vessels that come into view are divided between two clamps and tied.

The next step is to divide the tendon of the lesser pectoral muscle near the coracoid process (Fig. 804). Just beneath this tendon lies the subclavian vein. The surgeon now makes a transverse division of the fascia over the axilla, and thus exposes the axillary and subclavian veins (Fig. 805).

Meyer's third step is to split the axillary fat over the upper portion of the latissimus dorsi up to the axillary vein, "thus dividing it from the mass of fat that enters the sulcus bicipitalis brachii."

Next, the axillary and the subclavian veins are followed up to where the

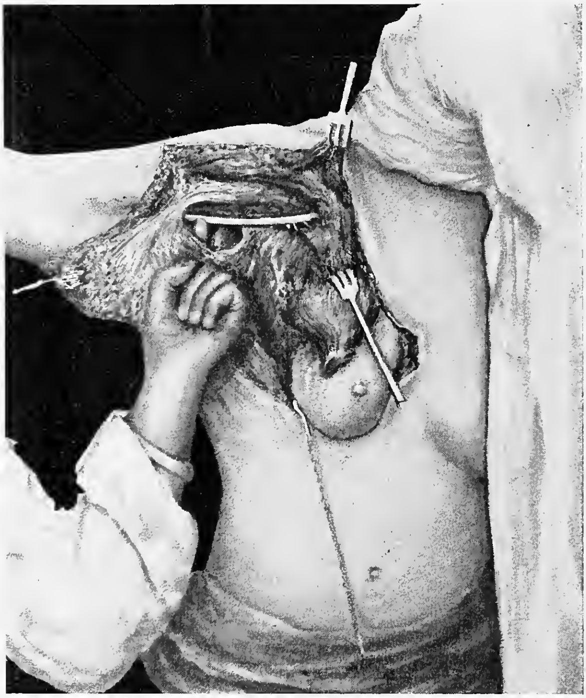


Fig. 805.—Willy Meyer's operation for carcinoma of the breast. Subclavian and axillary veins fully exposed. So far, glands and fat tissue not removed; smaller vessels still in connection with main trunks. Finger under fat toward sulcus bicipitalis, its nail resting on axillary vein.

subclavian passes below the clavicle, and every vessel that evidently must be cut is divided between two ligatures and tied. This procedure saves a great amount of hemorrhage. Meyer directs us to be careful to preserve the two superior subscapular nerves, although the third subscapular must be sacrificed.

The next step in the operation is to have the assistant hold up the mass of partly loosened tissues without pulling upon them; for if he does pull upon them, Meyer truly says, he is apt to tear off pieces of periosteum or perichondrium; and such bare spots are liable to become necrotic. The surgeon now cuts to the wall of the chest, being careful not to damage the great serratus muscle. Meyer cautions us at this step to hold the blade of the knife horizontal; that is, "perpendicularly toward the thorax." "If he (the surgeon) should not thus turn the blade of his knife, but cut perpendicularly downward toward the subscapular muscle, he would enter the fat covering and enveloping

the nerves and blood-vessels of this region, thus running the risk of unnecessarily causing considerable hemorrhage and of injuring the subscapular nerves. In the general run of cases this region need not be explored; only in very advanced cases did I find a few injected glands in this area."

The pectoralis major muscle is now divided close to the wall of the chest, the cuts being parallel to the ribs, and almost level with them; and the mass being gently drawn toward the sternum. By watching carefully, one may see the perforating arteries and veins drawn out by traction before cutting them, and may usually catch each of them with two clamps and divide be-

Fig. 806.—Willy Meyer's operation for carcinoma of the breast. Pedicle of mass over sternum ready to be cut off.

tween the clamps. If this is impossible, they are divided and quickly picked up. The last tissue that holds the mass to the chest-wall is composed of the muscle-fibers from over the sternum. These are divided close to the sternum (Fig. 806). The final steps consist in tying all blood-vessels, draining, and suturing the wound.

This operation has noteworthy merits. It can be performed far more rapidly than can any other method that I have ever employed. The loss of blood is comparatively trivial, because in this operation the chief blood-vessels are divided close to the axillary artery and tied. In removing the mass from the chest-wall there is little bleeding, except what comes from the perforating vessels, hemorrhage from the branches of the axillary being entirely absent; and even many of these perforating vessels are *cut* and tied before being *divided*.

Inoperable Malignant Diseases of the Breast.—This term implies that a radical operation looking to cure is impossible. The conditions in

which it is impossible have already been specified (page 1236). Even if the case is judged inoperable from the radical standpoint, it may be wise to remove the mammary gland, in order to free the patient from a hideous, ulcerating area, violent pain, and harassing hemorrhage.

It has been suggested that some cases inoperable by ordinary methods may be subjected to removal of the entire upper extremity or to disarticulation at the shoulder-joint with some prospect of cure. My own view, however, is that when a case has advanced so far that it is not amenable to ordinary operative treatment, neither of the above-mentioned procedures offers any reasonable chance of success. If the pain is extremely violent in an inoperable case, the surgeon may relieve it by dividing the brachial plexus, or perhaps by disarticulating at the shoulder-joint.

An inoperable case may be greatly improved—for a time, at least—by the use of the *x*-rays; and even when the condition is not benefited in other ways, this new force sometimes mitigates or greatly relieves the pain.

Beatson's Operation, or Double Oöphorectomy.—It has been pointed out by this surgeon that there is a certain similarity between the formation of cancer in the mammary gland and the process of lactation. In each there is an enormous production of embryonal epithelial cells; but in lactation the epithelial cells undergo fatty degeneration, and in cancer-formation they do not do so, but penetrate into the tubules and the acini and infiltrate the gland-structure. Beatson further points out that when a lactating cow is spayed, it continues to give milk indefinitely. This seems to indicate that removing the ovaries favors the fatty degeneration of the epithelial cells. This operation has been performed in cases of inoperable carcinoma of the breast, in the hope of bringing about degeneration in the tumor-mass. In the great majority of cases it fails utterly; but now and then it secures a notable improvement, and in a very few cases cure seems to have been obtained. Abbe obtained an apparent cure in two patients. It was at first thought that the operation would be applicable only to persons that have not passed the menopause, but one of Abbe's patients was over seventy years of age. Butlin, however, says that there is no genuine cure secured by this operation on record. My own view is that the procedure offers but little prospect of success, but that, as it does offer some, the exact facts should be placed before the patient, and she should be permitted to choose whether or not she wishes the operation performed. The operation is not to be considered, however, if visceral deposits exist.

XXXIX. SKIAGRAPHY, OR THE EMPLOYMENT OF THE RÖNTGEN RAYS. THE FINSEN LIGHT; BECQUEREL'S RAYS; RADIUM RAYS.

The cathode rays were discovered by Hittorf, in 1869, while passing an induction current through a vacuum tube. Crookes, of London, greatly improved the vacuum tube, and obtained a rarefaction which left in the tube but the one-millionth of an atmosphere. This last-named observer found that when an interrupted current of high potential is passed through a vacuum which is nearly perfect, fluorescence takes place. In a Crookes tube the positive electrode is placed at some indifferent point, and the current from the negative electrode flows not to the positive, but directly to the wall of the tube opposite the cathode, and at this point the phosphorescent glow is detected.

In 1895 Röntgen, of Würzburg, while making a study of cathode rays as developed in Crookes's tubes, discovered the energy which he named the *x*-rays. Röntgen showed that at the wall of the Crookes tube opposite the negative electrode a new and hitherto unknown energy is generated. Because of the uncertain character of this energy he gave to its manifestation the name of the *x*- or unknown rays.

The *x*-rays are invisible; cannot be deflected, reflected, refracted, or concentrated; are not influenced by the magnet; and produce none of the ordinary recognized effects of heat. The rays can be polarized and travel with the velocity of light. They cause fluorescence in certain substances, notably in tungstate of calcium (Edison), platinocyanid of barium (Röntgen), and platinocyanid of potassium. They have a marvelous power of penetration, and pass through many substances which are opaque to sunlight, ultraviolet light, and ordinary electric light. They are readily transmitted by water, organic substances, leather, cloth, paper, and flesh. Bone transmits them less easily, and metal still less easily, and both these materials cast shadows, but no substance absolutely prevents their transmission. An ordinary dry photographic plate is sensitive to the rays, and they cause an electrified body to discharge. If the rays are intercepted by a body not readily permeable which is placed between the Crookes tube and the photographic plate, a shadow will be cast, and a picture of this shadow will be formed upon the plate. Such a picture is known as a *skiagraph* or *radiograph*. If a body more or less resistant to the rays is placed between the tube and a fluorescent screen, the body casts a shadow on the screen, and the portion of the screen free from shadow glows with fluorescence. Such a screen is known as a *fluoroscope*. It will thus be seen that the *x*-rays enable the surgeon to look beneath the skin and to see those things which before the discovery of Röntgen were unseeable during life.*

The real nature of the *x*-rays is unknown. They are not light rays, although they travel with the velocity of light and can be polarized, but they cannot be reflected or refracted. They are not heat-rays. They are not ultraviolet rays, although they resemble ultraviolet rays in causing fluorescence, in effecting a sensitized photographic plate, and in causing an electrified body to discharge (Turner). Röntgen thinks they are longitudinal ether-waves. L. Herschel Harris ("Australasian Med. Gaz.," Jan. 25 and Feb. 20, 1902) says it is generally believed that they are transverse ether vibrations of short period, wave-like in character and produced by a bombardment of the anticathode with highly charged molecules from the cathode. Monell says: "They appear to be originated at the site of the greatest electrical activity within the tube, and their real nature is as unknown as the nature of heat, gravity, electricity, mind, and of life itself."

Sir George Stokes regards them as irregular impulses in ether comparable to noise (Dawson Turner, "Brit. Med. Jour.," Dec. 12, 1903). The *x*-rays are not germicidal, but do produce inflammation. The clinical effects may, perhaps, be due to the rays themselves, but may be due in part to the "electro-

* See particularly Röntgen's report to the Physico-Medical Society of Würzburg, Dec., 1895; also the article upon the *x*-rays by S. H. Monell, in the Brooklyn Med. Jour., May, 1896. "The Röntgen Rays in Therapeutics and Diagnosis," by W. A. Pusey and E. W. Caldwell; "Fractures," by Carl Beck; "The Röntgen Rays in Medicine and Surgery," by F. H. Williams. L. Herschel Harris, in Australasian Med. Gaz., Jan. 25 and Feb. 20, 1902. J. Rudis-Jicinsky, in N. Y. Med. Jour., March 23, 1902. Carl Beck, in Jour. Am. Med. Assoc., Jan. 5, 1901. C. L. Leonard, in Annals of Surgery, April, 1901, and in Jour. Am. Med. Assoc., July 21, 1901.

static and ionization around the tube" (Dawson Turner, "Brit. Med. Jour.," Dec. 12, 1903).

To obtain the rays a good apparatus is essential. An ordinary medical battery is incapable of producing them, as it is absolutely necessary to have a current of high tension. The discoverer used a Ruhmkorff coil, but this is by no means the most satisfactory apparatus to employ. Some experimenters have made use of a "powerful static machine and transformer coils" (Monell). Swinton uses twelve half-gallon Leyden jars and discharges them through the primary coil, the secondary circuit being a Tesla oil coil.

The current is best taken from the street-light circuit. Monell says that this current should be controlled by an interrupter, the interruptions of which are 100 per second. The interrupted current is to be passed into an induction coil, and the secondary current is to be conveyed into the Crookes tube by two wires. The secondary current thus produced will furnish a spark five or six inches long. In order to take a skiagraph of deep structures a high vacuum should be used. For x-ray therapy the ordinary tube should not be used because the intensity of the vacuum is too changeable. A tube with a definite or controllable vacuum is required for such work.

When the surgeon is about to use the x-rays, he must remove from the person of the individual anything that might cause confusion or lead to error. If the foot is to be examined, remove the shoes, because shoes contain nails; if the hand is to be examined, remove the gloves if they are fastened with buttons of bone or metal; if the thigh is to be examined, remove coins, keys, knives, etc., from the pocket; a garter, if it has a metal clasp, should be taken off.

In order to get the best results from the Röntgen rays, not only must the apparatus be good, but the man who uses it must be expert. Pictures taken by an unskilled man lack clearness of outline, and may even lead to positively erroneous conclusions. Nevertheless, a person accustomed to the employment of scientific apparatus can very soon become sufficiently expert to take fairly clear pictures which should not lead to error. Maurice H. Richardson * maintains that the Röntgen rays can be employed successfully in the routine office practice of a general practitioner.

The surgeon may utilize the x-rays by means of a *fluoroscope*. Edison's fluoroscope consists of four sides of a box, one end being open and made to fit tightly over the observer's eyes, the other end being closed with cardboard made fluorescent by smearing it with mucilage, and, before the mucilage is quite dry, sprinkling it with crystals of tungstate of calcium. If it is desired to examine the hand with a fluoroscope, the extremity is held opposite an excited Crookes tube and from six to ten inches away from it; the end of the fluoroscope, which is covered with fluorescent paper, is placed near the surface of the hand which is away from the tube, and the observer looks through the other end of the instrument. The flesh seems but a dim haze, and the shadows of the bones are distinctly outlined. The fluoroscope can be easily used, and gives reliable results in studies upon the hands and feet, but when deeper structures are to be investigated, or when absolute accuracy is essential, it is better to take a skiagraph. The value of fluoroscopy is constantly increasing as better electrical appliances and Crookes's tubes are being made.

If thick tissues require to be penetrated by the rays, if great accuracy is necessary, or if a permanent record is to be retained, a skiagraph must be

* Med. News, Dec., 1896.

taken. In taking these pictures dry plates can be used; the plate need not be removed from its wooden case during the process, and it is not necessary to conduct the proceeding in a dark room. The tube should be from twelve to fifteen inches away from the surface of the body. The plate must be fastened to the surface *exactly opposite* the tube. It is necessary to observe care in the adjustment of the plate, because the *x*-rays travel only in straight lines, and any carelessness of adjustment will lead to curious and misleading aberration in the picture. The length of exposure necessarily varies with the thickness of the tissues, the structure of the part, the nature of the body we wish a picture of, and the perfection of the apparatus. The time may be from three minutes to thirty minutes or more, although with our improved apparatus prolonged exposures are now seldom permitted. The *x*-rays, like the ultraviolet rays, produce hyperemia which may be followed by pigmentation and later by atrophy. According to Ormsby, those who tan in sunlight are apt to soon develop pigmentation under the use of the *x*-rays. Prolonged exposure is undesirable if it can be avoided, as it may produce an *x-ray* "*burn*," a condition which should be called *x-ray dermatitis*. Those who tend to burn in sunlight are liable to *x*-ray dermatitis (Ormsby). The use of an improper apparatus or placing the tube too close to the body may be followed by a burn. Occasionally, in spite of the utmost care, injury will be done by the *x*-rays. In treating a malignant growth by the *x*-rays the adjacent healthy tissue is protected from burning by a covering of lead-foil.

The so-called *x*-ray "burn" is not a burn at all. A burn is due to the contact of heat, begins upon the surface, is accompanied with pain from the moment of application, and is followed by inflammatory changes, beginning on the surface. An *x*-ray "burn" is not manifest for several days or even several weeks after the application of the rays, at which period an inflammatory or a gangrenous process arises, which begins within the tissues and subsequently involves the surface.* The condition is really *x*-ray dermatitis. In rare cases there is elevation of temperature lasting for a few days and ceasing when desquamation becomes marked or epidermization evident (Guido Holzknecht). Inflammation may pass away or may eventuate in gangrene, and a gangrenous area is white in color, "leathery, stringy, tough" (Hopkins). Hopkins calls the process "*white gangrene.*"† These burns are often accompanied by loss of hair or nails in the damaged area; they require months to heal, if they heal at all, are very painful, and are not improved by the treatment which relieves ordinary burns. In some cases the consequences are very serious. In a case reported by J. P. Tuttle it became necessary to amputate the thigh.‡ Those who apply the *x*-rays regularly and frequently are apt to develop destructive lesions of the hands. In several of them cancer has arisen. The lesions occasionally produced by the *x*-rays are probably trophic changes. Sections made by Vissman from Tuttle's case indicated that the lesion was a gangrenous process due to arteritis of the smaller vessels. Various theories have been advanced to account for the occurrence of *x*-ray gangrene, viz.: liberation of ozone in the tissues (Tesla); interference with cellular nutrition caused by static electric currents "induced by the introduction of the patient's tissues into the high potential induction-field surrounding the tube" (Leonard); the destruction of the nerve-supply of the tissue (Hop-

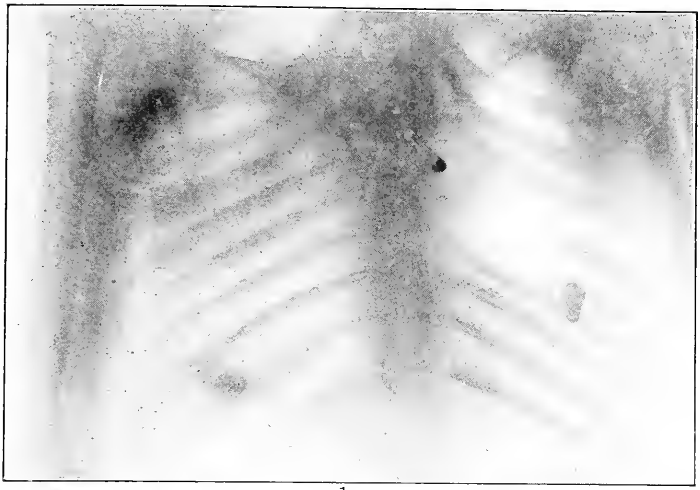
* E. B. Bronson, in the debate on J. B. Tuttle's case, Med. Record, March 5, 1898.
† G. G. Hopkins, Phila. Med. Jour., Jan. 6, 1900.
‡ Med. Record, May 5, 1898.

kins); irritation of the peripheral extremities of the sensory nerves, causing paralysis of the vasomotors (Rudis-Jicinsky); an electrolytic action of a current generated in the tissues by induction from the tube (Judd). These x-ray injuries are most liable to occur when a Ruhmkorff coil is used, and such a condition is very rarely caused by a static machine. Hopkins says the lesions "are produced more frequently by tubes that are energized by alternating currents than by those energized in any other way." He has only found record of four cases produced when a static machine was used. It has been suggested that a thin piece of aluminum, a plate of platinum, or a sheet of gold-leaf placed upon the part while it is exposed to the x-rays will prevent the occurrence of these injuries.

A recent x-ray burn may be treated for a time with vaselin. No irritant application should be employed. In a non-ulcerated area the itching will be allayed and repair favored by a preparation used by Dr. Martin F. Engman ("Interstate Med. Jour.," July, 1903). It consists of 12 drams of boric acid, 1 ounce of zinc oxid, 1 ounce of starch, 1 ounce of subnitrate of bismuth, 1 ounce of olive oil, 3 ounces of lime-water, 3 ounces of lanolin, and 12 drams of rose-water. The powder is rubbed in a mortar, the lanolin is added. The olive oil and lime-water mixed are slowly added to the powder and lanolin. The mixture is stirred, the rose-water is added, and the preparation is beaten into a creamy paste. If itching is severe, 1 to 2 per cent. of carbolic acid is added. The paste is spread on several thicknesses of gauze and the gauze is covered with a rubber dam. When ulceration occurs, dressings of normal salt solution may prove of benefit. Skin-grafting may succeed in remedying an ulceration following an x-ray injury; but, as a rule, the grafts do not grow, or if they adhere are very apt to break down after a time. In many cases the best treatment is excision (Powell). Can the x-rays cause death? Death may follow a burn without being directly due to it. There are 4 reported cases in which death followed x-ray burns, but in not one case is it certain that the burn was directly responsible (Rubel, in "Jour. Amer. Med. Assoc.," Nov. 22, 1902).

The uses of the x-rays are legion. They are of the greatest possible value in the location of foreign bodies, especially bodies of metal, glass, or bone, such as bullets and needles, glass, splinters, etc. Bullets are readily detected in the extremities; have been found in the lung-substance and bronchi (Rowland), in the brain (Schier, Brissaud and Londe, Keen and Sweet, Henchen and Sennauer, Bruce, Willy Meyer), in the abdomen, the pelvis, a joint, the spine, and the eye. The x-rays will enable us after an abdominal operation to locate a Murphy button and tell when it has loosened and descended. Foreign bodies, especially if metallic, in the esophagus, stomach, intestine, and air-passages; enteroliths and mineral calculi in the salivary ducts, bladder, ureter, and kidney can be detected. Henry Morris tells us that a calculus in the kidney may exist and yet escape detection with the rays, because the kidney is very deeply placed, is under the ribs and close to the vertebral column. Occasionally a drainage-tube lost in the pleural sac may be discovered. Most observers state that gall-stones cannot be skiagraphed in the living body. Cattell has succeeded in one case and Carl Beck has succeeded.* The rays may fail to disclose a foreign body because of its being overshadowed by a bone (Carless), but prolonged exposure or the taking of another picture with the part in another position will bring it into view. In many cases a

*N. Y. Med. Jour., Jan. 20, 1900.



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1. Gunshot-wound of the Lung. Rib-resection for secondary hemorrhage into the pleural sac ten days after the injury; bullet not removed. Hemorrhage arrested by packing with gauze. Skiagraph taken three months afterward shows the bullet. (Author's case.)

2. Fracture of Lower End of the Femur. Reduction of fragments impossible because of the interposition of a loose piece of bone and much muscle between fragments. (Author's case.)

3. Case shown in Figure 2, Three Months after the Operation of Wiring. Nine months after operation, the man is walking about with ease, and the wire is still in place.

(The above skiagraphs are from the X-Ray Laboratory of the Jefferson Medical College Hospital.)

A

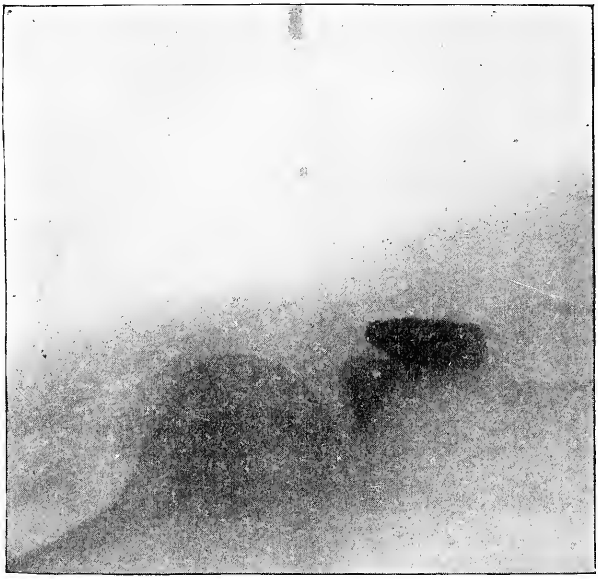

Fig. 808.—Skiagraph made with tube horizontal to plane of indicators. The bullet is well seen Opposite *A* are seen the two balls at the ends of the rods.

A *B*

Fig. 809.—Skiagraph made with tube above horizontal plane of indicators. The bullet is well shown Opposite *A* and *B* are seen the two balls at the ends of the rods.

foreign body preserves at all times a fixed relation with respect to the shadows of the two indicator-balls in whatever position the tube is placed, and since the situation of the two balls is known, the location of the foreign body in the tissues is readily determined from a study of the planes of shadow at the two exposures.

"When the skiagraphs of the case here reported were made, the anterior surface of the leg was placed upon the bottom of the right-angle support of the apparatus, the plate to the inner side of the knee, one indicator-ball resting on the skin nearly in the center of the popliteal space. The skiagraph made with the tube horizontal with the plane of the indicators is shown in Fig. 808, and the second skiagraph with the tube a short distance above the first position is seen in Fig. 809. Both negatives show the leg as viewed from the outer side, with the posterior surface of the leg uppermost.

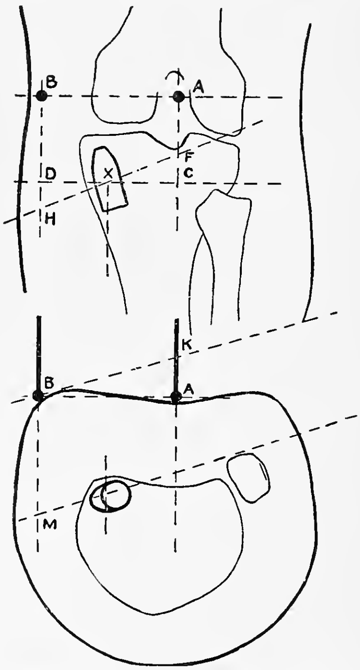

Fig. 810.—Method of indicating location of bullet. Upper diagram, posterior view of leg from above. Lower diagram, cross-section of leg, near knee-joint.

"In determining the position of the bullet a spot is made upon paper to indicate the point on the skin at which one of the indicator-balls rested at the time of the exposure, a second spot being made two inches from the first, to represent the fixed distance between the two balls. These are shown at *A* and *B*, upper diagram, Fig. 810. The first negative is now taken. The distance the shadow of the bullet is below the shadow of each of the two indicators is measured, and this distance entered below the spots representing the two balls when the exposure was made (*C* and *D*). A line drawn through these points indicates the plane of shadow of the bullet when the first skiagraph was made. Similar measurements are made from the second negative and marked below the spots *A* and *B*, the line through the spots (*F* and *H*) giving the plane of shadow when the second negative was made. Where these two planes of shadow cross (*X*) is the position of the bullet as measured below, and to the inner side of the nitrate of silver spot on the skin.

"In determining the depth of the bullet in the tissues, a second diagram is made to indicate the position of the two balls, as viewed from a cross-section of the leg. Since the tube was only twenty-four inches away at the time of the exposure, the convergence of the rays in an object as large as the leg must be allowed for. This is done by measuring the distance the shadow of one ball is behind that of the other, entering this distance (*A K*) on the diagram, and marking on a line through this point, twenty-four inches from the ball resting on the skin, the situation of the tube. If we now measure the distance

the shadow of the bullet on the first negative is back of that of the shadow of the ball on the skin, enter this distance in the plane of this indicator (*B M*), and draw a line from the situation of the tube through this point, we obtain the plane of the shadow of the bullet when the exposure was made. Drawing a line from the position of the bullet as previously found on the first diagram, the intersection of this line with the plane of shadow upon the second diagram gives the situation of the bullet from a cross-section view of the leg. For purposes of greater clearness, outlines of the leg have been shown in the two diagrams, although this is unnecessary in practice, since the position of the foreign body in respect to a known point upon the integument is all that is required. The position of the bullet was shown to be one inch toward the inner side of the spot on the skin at which one of the indicator-balls rested, one and a quarter inches below this spot, toward the ankle, and embedded in the tissues to the depth of one and a half inches. Both skiagraphs show the bullet close to the bone, but, owing to the false projection, so common in all *x*-ray pictures, it is impossible to say whether the bullet was embedded in the bone or not." Morris tells us to be somewhat skeptical in accepting unreservedly the evidence offered by a skiagraph, as slight carelessness in taking the picture may mean great distortion and consequent error.

In detecting fractures and dislocations the Röntgen rays are of great value, especially when there is much swelling, when there is little displacement, and when the fracture is in or about a joint. The rays enable us to determine the nature of the injury, the amount of splintering, the existence of impaction, the question whether or not the fragments are in contact and can be brought into contact; the direction of the line of fracture, the variety of deformity, the existence of more than one fracture, the presence of epiphyseal separation or dislocation alone or with a fracture, the existence of an ununited fracture, and the question if the splints are holding the fragments in accurate apposition. Fractures of the skull, if involving both tables of the vault, may be recognized; it is possible that fractures of the inner table may be found; fractures of the base can be seen, but with difficulty. Fractures of the spine can be skiagraphed, but never show very clearly. To take a picture of a fractured rib, first limit chest-motion by bandaging (White). The *x*-rays may be of value in enabling the surgeon to recognize rheumatoid arthritis; bone- and joint-tuberculosis (the tuberculous area being lighter than the sound bone); the amount of acetabular rim present in congenital dislocation of the hip-joint (Rowland); the state of the bones in a crushed limb (J. Hall Edwards); bone deformity; osseous tumors; bone displacement (as in Morton's foot); osteomyelitis; caries; necrosis; and osteosarcoma. By skiagraphy we are enabled to decide on the proper situation to perform osteotomy, and if a deformity of the foot can be amended without operation (Willard). The position of the fetus in utero can be definitely made out.

Applied to the soft parts, the new process has obtained interesting but not as yet many practically useful results. Fibrous tumors can be seen, but malignant tumors, unless they contain calcareous or fibrous elements, cannot be definitely made out; loose bodies in a joint can often be detected. The shadow of the heart can be made out, and the outlines of the diaphragm, kidney, and liver can be thrown upon the screen. If the stomach is distended with gas, it shows as a light area upon a dark background (Hedley). If food is

eaten after being mixed with subnitrate of bismuth, the outline of the viscus becomes fairly distinct. Thickened pleura, pleural effusion, pulmonary consolidation, abscess of the lung, pericardial effusion, aortic aneurysm; cavities in the lungs, and atheromatous blood-vessels may be made out with more or less distinctness. If a sinus is injected with iodoform emulsion, a picture of it can be taken, because the emulsion casts a shadow when placed in the path of the *x*-rays (J. Hall Edwards).

The X-rays in Malignant Disease.—Of late the surprising fact has been demonstrated that *x*-rays may alleviate, or even, it may be, cure, malignant disease. So far it does not seem likely that internal cancer can be notably affected, although even in these cases the rays seem to lessen pain. Surface epitheliomata may entirely disappear and enlarged lymphatic glands associated with epitheliomata sometimes shrink up and pass away. In two dreadful cases of inoperable and recurrent cancer of the face with extensive lymphatic involvement in which the rays were used I have seen apparent cure result. Unfortunately, the cure is more apparent than real, and in every case which I have watched the growth has begun again after weeks of apparent immunity and has progressed with fearful speed. Nevertheless, it is most important to know that we have a remedy which relieves pain even in advanced cases, lessens bleeding and discharge, and which will often for a time arrest the ravages of this fearful malady, prolong life, and add to comfort when nothing else is of avail. It may be that with increase of knowledge we may learn that an apparently cured case can be kept well by the continued use of the rays from time to time. Francis H. Williams says that for this work a good-sized static machine or coil is needed and the spark-gap should be adjustable. If the growth is superficial, a tube of low resistance is used; if it is deeper, one of high resistance is employed. The tube is placed in a holder, the interior of which is painted with white lead. A screen of lead is used to reduce the cone of the rays to a size but little larger than that of the area to be treated. If cavities are to be treated, the rays are passed through a cylindrical speculum of glass, which is surrounded by a sheet-tin shield.

At each sitting the exposure is from five to ten minutes in the beginning, but later it may be increased to twenty minutes or more. Three or four exposures a week are given. Williams points out that a rapidly growing tumor should receive an exposure of not more than five minutes; and that if, a day or two later, there is pricking and slight irritation, these signs should be regarded as distinctly favorable (Dr. Francis H. Williams, before the New York Academy of Medicine, March 6, 1902; reported in the "Med. Record," March 15, 1902).

It may be very quickly determined whether the *x*-rays will help the patient or not. For instance, if an epithelioma is going to be benefited, it will begin to show improvement within two weeks.

Some observers have maintained that the beneficial effects are due to burning with the *x*-rays. Dr. Carl Beck thinks that they are obtained only when the integument alone is involved. Dr. A. G. Ellis ("Amer. Jour. of Med. Sciences"), from a series of studies made in the laboratories of the Jefferson Medical College, has reached the conclusion that endarteritis is induced by the *x*-rays; but that, as the accompanying tissue-necrosis is out of pro-

portion to the vascular changes, it is possible that the necrosis does not result from the vascular changes, but that each condition results from the same influence. He has further concluded that the x-rays do not possess any definite germicidal power. Some observers attribute to actinic action the tissue-changes wrought by the x-rays; others, to phagocytosis and leukocytosis. It is certain that the x-rays are irritant and tend to produce inflammation. In an inflamed area stasis occurs, and about an inflamed area leukocytes gather. Hence, degeneration may occur or actual sloughing take place. The embryonal cells of cancer are acted upon more strongly than normal tissue-cells. Sarcoma is not so apt to be benefited as carcinoma.

THE FINSEN LIGHT.

It is known that below the spectrum of white light are heat rays and above the spectrum of white light are short violet, actinic, or chemical rays. The short violet, with the indigo rays and blue rays, constitute the Finsen light. Ultraviolet rays cause an electrified body to discharge, excite fluorescence in certain substances, affect a photographic plate, and are bactericidal but have little power of penetrating tissues and, it is said, do not inflame tissues. Ultraviolet rays pass readily through rock salt or ice, which will not transmit heat-rays.

Finsen taught us to use these rays therapeutically. He first obtained the rays from sunlight, intercepting the heat-rays by ice or rock crystals. Later he obtained them from the arc light.

Blood in part prevents the passage of the Finsen light, hence in using the light we must make the area on which the rays are to act nearly bloodless. This is done by pressing firmly upon the part with a rock crystal through which water passes. The rays pass through the crystal and the water absorbs the heat-rays. The rays are especially serviceable in lupus.

BECQUEREL'S RAYS.

Becquerel discovered in 1896 that uranium and some of its compounds give off a radiation similar to but much weaker than the x-rays. Among these radiant substances are pitchblende, radium, and uranium. These rays are luminous, actinic, and skiagraphic (McFarland), and may produce, by prolonged action, dermatitis similar to an x-ray dermatitis.

RADIUM RAYS.

Monsieur and Madame Currie, after prolonged research, found that thorium and certain ores of thorium and uranium (pitchblende) are radio-active, pitchblende being more strongly so than uranium itself. The conclusion was that pitchblende contained a strongly radio-active element and that it was not uranium. In 1903 they discovered the sources of radio-activity to be two hitherto unknown elements, radium and polonium (see Dawson Turner in "Brit. Med. Jour.," Dec. 12, 1903).

Turner tells us ("Brit. Med. Jour.," Dec. 12, 1903) that radium gives off a radio-active emanation and three kinds of rays (α-rays, β-rays, and γ-rays). It also emits heat, and is itself at a higher temperature than the medium in which it rests. The emanation from radium is a luminous gas, which can be condensed by great cold, and which imparts radio-activity to certain

bodies. It is to this gas that most of the curative effects of radium can be attributed.

Turner shows that α-rays consist of a stream of positively charged gaseous particles each about twice the size of a hydrogen atom, and travelling at a velocity of 20,000 miles a second and having little power of penetration. The β-rays consist of particles each being $\frac{1}{1000}$ the size of a hydrogen atom and being strongly actinic. These rays are said by Turner to resemble cathode rays and to be more penetrating than α-rays. γ-rays resemble x-rays and have great penetrating power (Dawson Turner, in "Brit. Med. Jour.," Dec. 12, 1903). It is probable that radium also generates, or helps to generate, a gas called helium, which has no action on tissues.

Radium is being used in the treatment of malignant disease and other conditions. It is employed in the form of bromid of radium. If carried in the pocket in a glass tube it produces violent dermatitis. Skiagraphs can be taken with its aid. The rays and emanations are germicidal. Water may be rendered radio-active by exposure to the rays and emanations from a tube of radium bromid, and such water has been drunk in the hope that it would benefit cancer of the stomach.

Abbe has obtained striking results in several cases of malignant disease by inserting in the tumor a tube of radium bromid and allowing it to remain some hours.

A man entirely blind cannot perceive light when radium is brought near him, but one not quite but almost blind can, and one quite blind to form but with retention of some light perception can actually see the shapes of objects near a screen rendered luminous by radium (Turner). Turner tells us that a man retaining vision, who covers his eyes, can detect radium held in a box behind his head.

XL. INJURIES BY ELECTRICITY.

Effects Produced by Lightning.—Every year in the United States about 224 persons are killed by lightning (McAdie). An individual may be struck directly, or he may be shocked by an induced current, the lightning having struck a nearby object. A person can be struck while in a room, but there is more danger when exposed, especially in the open country. To be under a single tree or under a tree at the margin of a forest during a thunder-storm is dangerous, but to be in a wood or under a hedge is reasonably safe. The oak is struck more often and the beech less often than other trees (Professor McAdie. Quoted in "Draper's Legal Medicine"). It is not safe during a thunder-storm to stand by a chimney or fireplace, in an open doorway, or close to cattle (Professor McAdie. Quoted in "Draper's Legal Medicine"). The victim of lightning may be killed instantly. Death is the fate of over one-third of those struck. Tidy states that out of 54 cases, 21 died and 33 recovered. Post-mortem examination may fail to reveal a lesion, but in many cases severe burns are discovered; in some there are laceration of tissue, crushing of bones, and fearful injury. Burns are especially apt to occur at the points where the current entered and emerged. The clothes are usually singed and torn. The typical lightning-marks are arborescent tracings, rep-

resenting the course of blood-vessels, produced by disorganization and effusion of blood as the fluid travels through it. Occasionally metal objects, such as buttons, knives, money, keys, etc., are fused, and spread as a metallic film over a considerable portion of the surface of the body. Bichat stated that in death from lightning rigor mortis does not occur. This statement is now known to be an error (see the three cases reported by M. Tourdes). As a rule, there are early rigor mortis, retained fluidity of blood, and distention of the brain with venous blood. The cause of death by lightning was supposed by Hunter to be destruction of muscular contractility, and by Richardson the resolution of the blood into gases. It seems probable that some deaths are due to actual disorganization of vital structure and that others are due to shock or inhibition. An individual struck by lightning may recover even when he is *apparently* dead. Sestier reported 77 cases struck by lightning, and in 7 of them the persons were apparently dead for a number of hours.* Brouardel says in such cases the death-like state may be ascribed to inhibition, caused by a *maximum* degree of stimulus.† When death from lightning is not immediate, the condition may be as above outlined, the individual being apparently dead, without obvious respiration or pulse. He may be insensible, with slow and labored respiration, a weak and irregular pulse, and dilated pupils, and may remain in this condition for a few minutes or for several hours. The above condition is not to be distinguished from severe concussion of the brain. Every individual suffering from the effects of lightning should have his entire body carefully examined to see if physical injuries exist (fractures, wounds, burns, ecchymoses, arborescent tracings). The consequences of lightning-stroke are many and various. There may be rapid and complete recovery, gradual recovery, traumatic neurasthenia, sloughing burns, partial paralysis, which is usually recovered from (Nothnagel), but which may be permanent; hysteria, blindness, change of character, and actual insanity.

Treatment.—Do not pronounce a person dead until a thorough attempt at resuscitation has been made. Do not give alcoholic stimulants. If the respiration is feeble and apparently absent, make tongue traction and employ artificial respiration. Apply the stream of a warm douche to the head, rub the limbs with mustard, put a mustard plaster over the heart and another to the back of the neck, wrap the individual in hot blankets, give enemata of hot saline fluid, and strychnin hypodermatically. In some cases venesection has seemed to be of benefit. When the individual reacts, treat any existing condition symptomatically, and treat particular physical injuries according to their character.

Effects of Artificial Currents.—Individuals may receive dangerous or fatal shocks by contact with wires carrying a powerful electric current, by contact with a dynamo, or with some metal object which has become accidentally charged by a powerful current. Workmen for electric companies, pedestrians in the streets of a city which is lighted by electricity or in which trolley cars are employed, roofers, and firemen are liable to be injured by electricity. During many fires in cities live electric wires fall and charge the rails of a street-car track, the iron of a hook-and-ladder truck, or water tower or a fire-escape. Firemen who come in contact with such charged material

* Sestier, "De la Foudre," Paris, 1866. Quoted by Brouardel in his lectures upon "Death and Sudden Death."

† Benham's translation of Brouardel's lectures upon "Death and Sudden Death."

are shocked. I have seen dozens of men thus shocked, but have as yet seen no fatal case. An alternating current is decidedly more dangerous than a continuous current of equal strength. The constant current causes a shock only as the circuit is opened and closed. While the current is passing continuously there is no shock, although dreadful burns may at this time be caused. The alternating current causes rapidly repeated violent shocks. The arc light is an alternating current. An artificial current acts like lightning. It may produce instant death; it may produce unconsciousness, delirium, stertorous respiration, Cheyne-Stokes' breathing, or clonic spasms. Its effects can be often recovered from. Not unusually the victim is apparently dead, but subsequently recovers. D'Arsonval reports the case of a man who was apparently killed by the passage of 4500 volts. No attempt at resuscitation was made for one-half hour, and yet he recovered when artificial respiration was employed. Donnellan reports a case of recovery after the passage of 1000 volts. Slight shocks may cause temporary numbness and even motor paralysis. An electric shock frequently causes burns or ecchymoses, and occasionally wounds. Wounds caused by electricity bleed profusely and are apt to slough. An *electric burn* looks like a blackened crust; it is surrounded by pale skin, and for twenty-four hours remains dry, when inflammatory oozing begins and the skin around it reddens. These burns are seldom as painful as are ordinary burns, but sometimes cause severe pain, and recovery requires a long time. When inflammation begins and suppuration occurs, tissue is extensively destroyed; tendons, bones, and joints may suffer; some portions become deeply excavated, and other portions show dry adherent masses of dead and dying tissue, and a burn which was at first small may be followed by a large area of moist gangrene;* lack of tissue-resistance, due to trophic disturbance, is largely responsible for the progress of the sloughing. Even an apparently trivial burn may be followed by extensive sloughing.

Treatment.—If a person is in contact with a live wire, the first thing to do is, if possible, to shut off the current. If it is not possible to shut off the current, catch a portion of the clothing of the victim and pull him away from the wire, but do not touch his body with the bare hand. If a pair of rubber gloves can be obtained, the subject can be moved with impunity and the wires can be safely cut. If it is not possible to drag a person away from electric wires, an individual can wrap his hands in dry cloth and safely lift the portion of the body in contact with earth or wire, and thus break the circuit and permit of removal of the body.† A dry cloth can be pushed between the body and the ground, and the body can then be removed from the wires. It may be possible to push the wires away by means of a dry piece of wood, or to cut them with shears which have wooden handles and which are perfectly dry. Treat the general condition in the manner set forth in the article on lightning-stroke (page 1256), that is, by external heat, artificial respiration, tongue traction, etc. Very severe burns may be caused. The author has dressed a number of electric burns with hot fomentations of salt solution during the first few days. This facilitates the separation of the sloughs and seems to aid the weakened tissues in resisting microbic invasion; after sloughs separate, the part

*See the article by N. W. Sharpe on "Peculiarities and Treatment of Electrical Injuries," in Phila. Med. Jour., Jan. 29, 1898.

†See the directions in Med. Record, Dec. 28, 1895, from Med. Press.

is dressed with dry sterile gauze. Antiseptic dressings can be used from the beginning, but they often fail entirely to arrest the sloughing. Iodoform produces much irritation and should not be employed. Ointments are very unsatisfactory. When the dressings are changed, the part should not be washed with corrosive sublimate, as this agent produces irritation; peroxid of hydrogen should be employed, followed by warm normal salt solution. Sharpe removes sloughs by applying the following mixture: 2 parts of scale pepsin, 1 part of hydrochloric acid, U. S. P.; 120 parts of distilled water. This mixture is washed off after two hours with peroxid of hydrogen. The same surgeon treats necrosis of bone by injecting every few hours a 3 per cent. solution of hydrochloric acid, using every second day the pepsin solution, and when necrotic areas come away, packing with gauze. When repair begins, the raw surface should be covered with silver-foil. Skin-grafting by Reverdin's method or Thiersch's method is rarely successful. In some regions it is possible to slide a large flap in place to cover a granulating area which will not heal. In a very severe case amputation or resection may be necessary.

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